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ASSOCIATION OF CHARACTERS IN PETUNIA

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Because of its popularity as a garden flower, and the many forms on the market, one would expect more to be known and published about the inheritance of characters in the petunia (*Petunia violacea* and *P. axillaris* and their derivatives).

A review of literature (1) shows that the inheritance of flower colours in petunia is as follows:

> Violet is dominant over red, and over lilac on a monogenic basis;
> Violet red is dominant over white with the F_1 colour intermediate;
> Uniform flower colour is dominant over flower colour with green margins;
> For other flower colours a more complex inheritance is reported.

Inheritance of flower type has been determined (1), namely:

> Single × single gives all singles, single × double gives a 1 : 1 ratio, and double × double gives about 3 doubles to 1 single in F_2.

In the inheritance of pollen colour in garden petunia four pairs of genes are involved (1).

Self-fertility in petunia has been considered to vary in degree. It has been shown that pollen tube growth is arrested in stylar tissue (2). From crosses made in the process of carrying out the studies presently reported the writer believes that much self-sterility thought to exist in petunia may be overcome by practising bud pollination. In fact, seldom were bud pollinations a failure in crosses involving the Flaming Velvet, Hollywood Star, and California Giant varieties of petunia.

Self-sterility was interpreted on the basis of four multiple allels by Harland and Atteck (3). When these workers selfed by bud pollination four normally self-sterile lines they obtained from the four lines:

One line which was dwarfed, one homozygous lethal line, and two lines normal in appearance.

Levan (4) has shown that sterility is influenced by chromosome number and complement, trisomic plants being more sterile than diploid plants. Levan also states, "Self-pollination certainly takes places frequently even in free flowering (open pollination) as the stamens in petunia dehisce already in the bud stage, and early pollination has always proven to give the best results" (p. 108 l.c.).

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EXPERIMENTAL

In 1940 a petunia breeding project was undertaken with a view to determining the mode of inheritance of certain plant characters of the petunia varieties Flaming Velvet (F.V.) and Hollywood Star (H.S.). The characters of these varieties with which the study is concerned are detailed in Table 1.

TABLE 1.—CHARACTERS OF PETUNIA VARIETIES

Character	Flaming Velvet	Hollywood Star
Plant	Vigorous, free-flowering, moderately large.	Of medium vigour, very free flowering, moderately small.
Leaf type	Normal	Wilty (might be called wiry).
Mature leaf index (Length: width ratio)	Low	Medium high.
Flower size	Medium large	Medium small.
Flower colour	Deep violet	Rose pink.
Corolla segments	Sinuses shallow, broadly pointed.	Sinuses deep, sharply pointed

Plants of parental varieties were grown to maturity in plant pots in the greenhouse at The University of Manitoba, Winnipeg. Hollywood Star was used as the pollen parent, and from crosses made, Flaming Velvet as seed parent, the first hybrid seed was harvested August 16, 1940. This hybrid seed was sown October 1, 1940, and the first hybrid plants bloomed February 25, 1941. The appearance of an F_1 plant in comparison with a Hollywood Star plant may be noted from Figure 1.

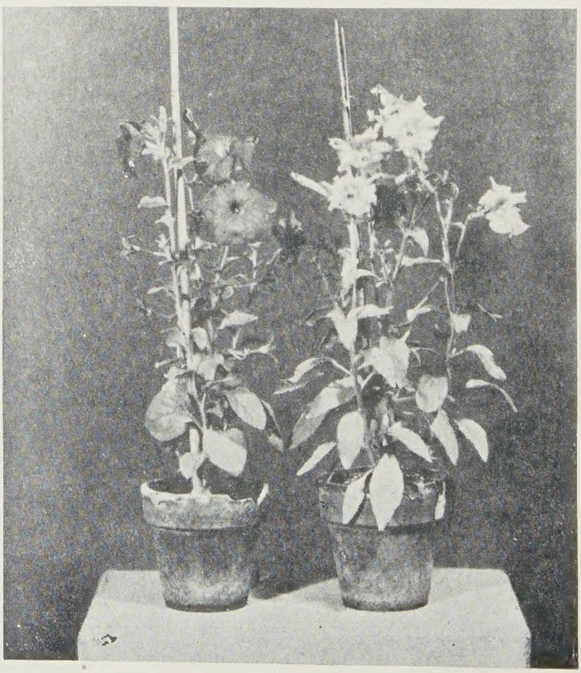

FIGURE 1. F_1 hybrid petunia plant (F.V. $\times$ H.S.) left. H.S. parent plant right.

It should be noted that the F_1 hybrid plant manifests none of the Hollywood Star characters previously described, having broader leaves, and producing flowers darker in colour, fewer in number and less deeply lobed. In other words it closely resembles the Flaming Velvet parent except that the flower colour is intermediate. As a bedding petunia it is very attractive.

Flower outlines of Hollywood Star and the F_1 hybrid are shown in Figure 2, so that a clear picture of the two flower forms might be obtained.

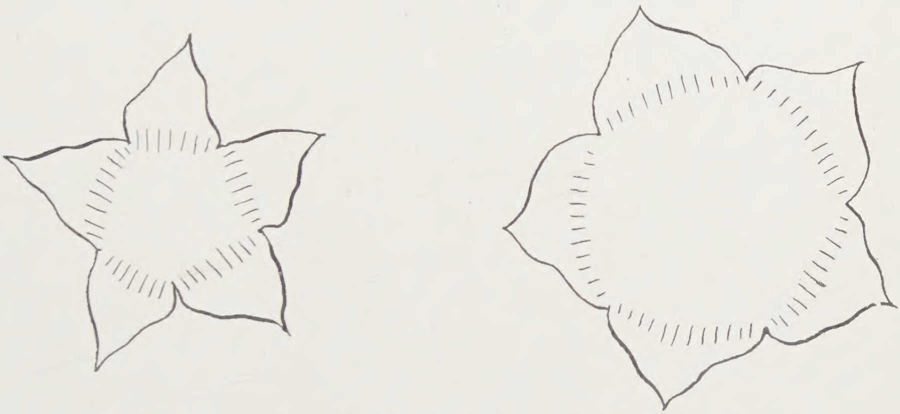

FIGURE 2. Hollywood Star (left); F_1 Hybrid (right) (natural size).

From mature Hollywood Star and F_1 hybrid plants dimensions of leaves and calyx lobes (presented in Table 2) were obtained. The average measurements given represent 48 determinations for each character.

TABLE 2.—AVERAGE LEAF AND CALYX LOBE DIMENSIONS OF HOLLYWOOD STAR AND F_1 HYBRID PETUNIAS 1941

Character		Hollywood Star	F_1 Hybrid (F.V. and H.S.)
Leaf	Length (mm.)	74.54	61.46
	Width (mm.)	21.90	28.48
	Length: Width (Index)	3.40	2.16
Calyx lobe	Length (mm.)	16.56	15.58
	Width (mm.)	1.83	2.56
	Length: Width (Index)	9.05	6.09

No attempt was made to obtain flower or corolla dimensions. That differences exist between leaves and calyx lobes of the H.S. parent and F_1 hybrid (F.V. $\times$ H.S.), the measurements given in Table 2 plainly show.

Some F_1 hybrid plants were allowed to self and produce seeds, but other plants were backcrossed with the H.S. recessive parent. In all controlled cross- and self-pollinations bud pollination was practised. This invariably resulted in early development of a high seed content in each seed capsule. From time of bud pollination to mature seed development in the petunias studied not more than 5 weeks elapsed.

To permit a preliminary study to be made of segregation in F_2 of characters considered in this cross, seeds from selfed F_1 plants were sown in The University of Manitoba greenhouse April 14, 1941. The seedlings were transplanted and grown to flowering stage in the usual procedure of handling flowering plant seedlings. Two progenies were carried to maturity and notes were taken as to plant types and flower forms of F_2 plants.

As will be realized, one seed capsule may contain many hundreds of seeds. When these seeds are sown under conditions favouring germination, no matter how favourable the environment, it is practically impossible to carry to maturity all of any one progeny; damping-off may destroy some plants, insects may further reduce the number, and through general and genetic weakness others may die prematurely.

RESULTS

The number of F_2 seedlings having F.V. and H.S. types of leaf were 126 and 12, respectively, giving a ratio of 10.5 : 1. This is not in good agreement with either the 3 : 1 or the 15 : 1 theoretical ratio. However, the plants with the H.S. type of leaf were on the average, of weaker constitution than the other types. As the germination of seeds sown and survival of seedlings were not complete it is probable that the embryos with the genotype for the H.S. leaf type survived in lower proportion than the others. If correction for this condition were possible it would modify the obtained ratio in the direction of a 3 : 1 ratio.

As will be seen from the following tables a number of the F_2 plants failed to bloom when data on blossoming were secured.

Tables 3, 4 and 5 show the results obtained when F_2 plants were classified for flower colour, leaf type, and corolla form.

TABLE 3.—CLASSIFICATION OF PLANTS AS TO FLOWER COLOUR IN TWO F_2 PROGENIES, 1941

Progeny	Colour of dark coloured parent (F.V.)	Intermediate in colour like F_1*	Colour of light coloured parent (H.S.)	Total
1	12	29	15	56
2	18	29	17	64
Observed	30	58	32	120
Theoretical (1 : 2 : 1 basis)	30	60	30	

* Flower colour of F_1 plants was intermediate between flower colours of parents; this finding is in agreement with results previously referred to during a review of literature (1).

Results in Table 3 indicate a monogenic basis for inheritance of flower colour, and this character did not seem to be associated with differential vigour of F_2 plants.

Tables 4 and 5 are presented in 2 × 2 form in order to show if association existed between the characters being studied. The data necessarily only included plants which bloomed.

TABLE 4.—FREQUENCIES OF F_2 PLANTS HAVING DIFFERENT LEAF TYPES AND COROLLA FORMS

		Leaf type		Total
		F.V. and Intermediate	H.S.	
Corolla Form	F.V. and Inter.	113	0	113
	H.S.	0	7	7
Total		113	7	120

P for independence = extremely small.
* Calculated by the direct probability method for 2 × 2 tables (5).

The data in Table 4 indicate a complete association between the leaf types and corolla forms studied. The *P* value shows that if these characters were inherited independently the probability of obtaining a distribution such as that actually obtained would be extremely small.

It will be noted that only seven plants (58%) of the original 12 H.S. type bloomed, whereas in the F.V. and intermediate class 113 (90%) of the original 126 bloomed. The weak constitution of H.S. type plants is believed to account for the low percentage which bloomed. These data are therefore not considered reliable as a basis for determining the factorial basis of inheritance of leaf type and corolla form. The close fit of the 113 : 7 distribution to a 15 : 1 ratio is considered to be coincidental.

TABLE 5.—FREQUENCIES OF F_2 PLANTS HAVING DIFFERENT LEAF TYPES, COROLLA FORMS AND FLOWER COLOURS

		Leaf type and corolla form		Total
		F.V. and Intermediate	H.S.	
Flower colour	F.V. and Inter.	81	7	88
	H.S.	32	0	32
Total		113	7	120

P for independence = 0.2134

In Table 5 the *P* value indicates that flower colour is inherited independently of leaf type and corolla form. The typical monogenic inheritance of flower colour has already been mentioned. The frequencies of plants in this table (81, 32, 7.0) are very similar to the theoretical frequencies based on a bifactorial inheritance of leaf type and corolla form, namely, 84.4, 28.1, 5.6, 1.0. But, as pointed out above, this is regarded as coincidental and conditioned by a heavy disproportionate loss of the H.S. type of plant.

BACKCROSS POPULATIONS

From the back crosses made in 1941 progenies from 4 seed capsules were developed in 1942 at The Forest Nursery Station, Indian Head, Sask.

The seeds were sown, and the seedlings handled under conditions whereby practically all seeds germinated, and losses of seedlings were kept at a minimum.

When the seedlings were being transplanted into flats from the seed pans, and later into the garden, no attempt was made to separate the individual seedlings. By setting out groups of 3 or more seedlings roots were disturbed very little, and large populations were handled with a minimum of care.

At maturity and when in full bloom the groups of plants were pulled, and the individual plants examined as to leaf type and flower form. Two classes were adapted for each character, as the so-called "intermediate types" resembled the F.V. type too closely to be given a separate classification.

TABLE 6.—FREQUENCIES OF BACKCROSS PLANTS HAVING DIFFERENT LEAF TYPES AND COROLLA FORMS (TOTAL OF 4 PROGENIES)

		Leaf type		Total
		F.V. and Intermediate	H.S.	
Corolla form	F.V. and Inter.	224	0	224
	H.S.	0	159	159
Total		224	159	383

P for independence = extremely small.

The backcross data in Table 6, like the F_2 data, show no crossovers between leaf type and corolla form. The association of these characters appears to be complete. The ratio of the frequencies of the two types is rather unbalanced for a backcross F_1 population. This is no doubt due to failure of a portion of the H.S. types to survive or to bloom. These were, on the average, as in F_2 progenies, less vigorous than F.V. types.

Any correction for this condition would make the obtained ratio approach 1 : 1 more closely. The actual data in Table 6 do not fit this theoretical ratio well as the χ^2 and P values for this fit are 11.03 and 0.01 respectively.

CONCLUSIONS

In the petunia cross Flaming Velvet × Hollywood Star, violet (F.V.) flower colour is partially dominant over pink (H.S.) and is inherited on a monogenic basis. The F_1 flower colour is intermediate between the parental flower colours.

Leaf type and corolla form of Flaming Velvet are dominant over the corresponding characters of Hollywood Star.

The factor or factors determining leaf type and corolla form studied appear to be either strongly linked or identical.

The factorial basis of inheritance of the leaf type and corolla form studied cannot be determined with a high degree of probability on the basis of the present data. Monogenic inheritance, however, appears to be the most likely in each case.

SUMMARY

The petunia variety Flaming Velvet which has broad leaves, violet flowers and broadly pointed corolla lobes with shallow sinuses was crossed with the variety Hollywood Star which has narrow leaves, rose pink flowers and sharply pointed corolla lobes with deep sinuses.

F_1 and F_2 populations as well as F_1 backcross populations of (F.V. $\times$ H.S.) $\times$ H.S. were examined with respect to the characters studied. Flaming Velvet type was in every case dominant, the dominance being only partial in the case of flower colour.

Flower colour appeared to be inherited on a monogenic basis, and independently of both leaf type and corolla form.

Leaf type and corolla form appear to be determined by factors which are closely linked or identical since no crossovers were obtained in the F_2 or backcross populations.

Plants with the Hollywood Star leaf type and corolla form were, on the average, of weaker constitution than other plants. This condition made a factorial analysis of inheritance unreliable. A monogenic basis for leaf type and for corolla form appears most probable.

FIGURE 3. Plants from same seed capsule F.V. type (left). H.S. type (right).

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STUDIES ON CROWN AND ROYAL FLAX IN FLAX-SICK SOIL

I. THE DETERMINATION OF CROWN AND ROYAL SEED SAMPLES BY GROWTH IN FLAX-SICK SOIL[1]

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Royal flax is a variety resistant to wilt (*Fusarium Lini* Bolley) under Saskatchewan conditions. It was developed by Dr. J. B. Harrington at the University of Saskatchewan as a selection from the wilt-susceptible variety Crown in the old wilt nursery (on block 505 of Bracken Field) during the period 1926 to 1941. It also shows a high resistance to rust (*Melampsora Lini* (Ehrenb.) Desm.) compared with Bison and Redwing, the two other varieties commonly grown in the province. The seed of Crown and Royal is medium in size and generally brown in colour, fading to pale yellow at the distal or wider end. It is consequently not possible to determine visually the exact identity of an unknown sample of these varieties. Primarily as a result of the flax-rust epiphytotic in 1942 and because of the need for increased flax production as a war-time measure, University and Government authorities recommended that Royal should replace Bison and Crown in the southern and central flax-growing areas of Saskatchewan, but that Redwing should still be grown in the northern park zone.

The replacement of Bison and Crown by Royal, for various reasons, must take several years. Its fulfilment was retarded by the limited supply of Royal seed from the 1942 crop, but with the increase in acreage of Royal in 1943, ample supplies should be available in the future.

In the late fall of 1942 growers began submitting flax-seed samples to the University of Saskatchewan and to the Dominion Seed Laboratory, Plant Products Division, Saskatoon, requesting variety determinations. The small brown seed of Redwing and the moderately large brown seed of Bison could readily be identified by seed analysts, but, as indicated above, the separation of Crown and Royal seed presented a problem. This separation could readily be secured by growing the unknown samples in the wilt nursery during the following summer, but to be of most help to the growers the information would have to be available before the spring sowing. Fortunately about 3 buckets of flax-sick soil had been collected from the new wilt nursery (on block 1203 of Bracken Field) before freeze-up in connection with flax-disease studies. Preliminary trials with known samples of Crown and Royal in this soil in the greenhouse gave severe wilt in Crown (82 to 92% in 5 small-scale tests), and a trace of wilt in Royal (0 to 3%). On the basis of these results routine tests were made in the greenhouse on 96 flax-seed samples of undetermined Crown and Royal, with the University strains of Crown and Royal as controls. The farm samples originated from country points in which all the major flax-growing

[1] Co-operative investigation between the Laboratory of Plant Pathology, University of Saskatchewan, and the Dominion Seed Laboratory, Plant Products Division, Saskatoon. Financial assistance to the University Laboratory was furnished by the Saskatchewan Agricultural Research Foundation.

[2] Professor of Plant Pathology.

areas of the province are represented. To test the reliability of the greenhouse method, 68 out of the 96 samples were tested for their reaction to blight and wilt in the new wilt nursery during the summer of 1943. The varietal identities of the 28 samples not included in the field test were quite definite; 11 of them determined as Royal gave 0.55% wilt in the greenhouse test, while 17 determined as Crown gave 93.0% wilt. Much of this testing was conducted in co-operation with Mr. T. W. L. Burke, Supervisor of the Dominion Seed Laboratory, Plant Products Division, Saskatoon, who supplied 87 seed samples and much of the help in seed sowing and the various counting operations.

These experiments were undertaken in an attempt to obtain a relatively quick and reliable means of settling the identity of doubtful Crown and Royal seed stocks or of indicating possible admixtures of these two varieties. The methods used and the results obtained in both the greenhouse and the field are presented in this paper. Until such a time as Crown has been entirely replaced by Royal in Saskatchewan, the greenhouse method may be of value to others who might find the need of making similar tests.

FIGURE 1. The identification of undetermined seed samples of Crown and Royal flax in flax-sick soil. R, Royal control; the other three pots at the left have been determined as Royal. C, Crown control; the other three pots at the right have been determined as Crown.

MATERIALS AND METHODS

The flax-sick soil used in the greenhouse experiments came from the new wilt nursery in which the field experiments were also conducted. This nursery (on block 1203) was started in the spring of 1940 by distributing flax-sick soil from the old nursery (on block 505) lightly over the surface and working it in. It was then sown to wilt-susceptible Crown during the three years 1940 to 1942 inclusive. In this last year more than 90% of the plants succumbed to wilt.

In the preliminary greenhouse experiments the undetermined Crown and Royal flax samples, with the University strains of these varieties as controls, were sown in the flax-sick soil in 6-inch pots with 25 seeds of each sample per pot (Figure 1). All subsequent experiments were conducted in large shallow flats 34 by 28 by 3 inches deep. Because of the limited

supply of soil 3 tests had to be run at different times, with each test having its own controls. Thus the greenhouse figures in Table 1 represent the averages of 3 tests for the controls and 1 test for each numbered sample. Fifty seeds of each sample were sown ½ inch deep and ½ inch apart in rows 1½ inches apart. Total germination counts were made when seedling blight began to show up in the Crown control; this was usually about 12 to 14 days after sowing, but varied with the temperature conditions. In another 12 to 14 days, or longer depending on the temperature, the seedling survivors were counted and the number of wilted seedlings per row was obtained by difference. The experiment was observed a few days longer

FIGURE 2. The section of the new wilt nursery in which the undetermined samples of Crown and Royal were grown. From visual examination alone it is easy to detect which of the four-foot rows are Crown samples (73 to 100% wilt), and which are Royal (less than 30% wilt).

and doubtful samples were given a second survival count. The percentage of wilt is based on the number of seedlings which emerged and not on the number of seeds sown. The same method of calculation was used with the field results. Samples in which the variety was not definitely indicated in the first test, or which might be mixtures of the two varieties, were given a second test. Varietal identity was determined primarily by comparing the percentage of wilt with those of the controls, but consideration was also given to the vigour of the surviving plants. In general, the survivors in the control rows of Crown were less vigorous than those in the control

rows of Royal. At the completion of the experiment the seedlings were hand pulled and as many of the fine roots as possible were removed from the soil with a home-made wire cultivator. The flax-sick soil was then diluted one-seventh with ordinary field soil, rested for 1 week and again sown to flax. The dilution did not appear to reduce the potency of the flax-sick soil, which had apparently reached its maximum. In this way the limited supply of soil was gradually increased.

The field test was conducted on 53 samples in the new wilt nursery (Figure 2) from which the soil used in the greenhouse tests was obtained the previous fall, and on 15 samples in an area of lightly infested soil adjoining this nursery. Varietal field determinations on these 15 samples were based on visual examination only. Each sample was sown in 2 randomized 4-foot rows with 200 seeds to each row. All rows were 8 inches apart. Total emergence counts were made on the 53 samples 21 days after sowing, and survival counts 33 days later. Calculations and varietal determinations were carried out as already described for the greenhouse tests.

EXPERIMENTS AND RESULTS

It should be emphasized that in these tests "percentage wilt" represents the percentage of post-emergence mortality of seedlings regardless of the causal organism involved, and not to *Fusarium Lini* alone. Thus isolations from diseased and dead seedlings have yielded *Rhizoctonia Solani* Kühn (*Pellicularia filamentosa* (Pat.) Rogers), *Pythium de Baryanum* Hesse and, to a lesser extent, *Fusarium* spp., in addition to *Fusarium Lini.*

The quantitative results of the comparative greenhouse and field tests of 53 seed samples together with the variety indicated are given in Table 1.

Samples Deserving Special Comment (See Table 1 on opposite page).

927—In its first greenhouse test this sample was recorded as indefinite, but in the repeat test it was considered to be Crown in spite of the moderate percentage of wilt (56%) as all the survivors were sickly. The field results supported this latter determination (100% wilt).

1310—This sample was recorded as "Royal?" (21% wilt) in its first greenhouse test. A second test gave 75% wilt; a third test was then made: this gave 77% wilt. In all of these tests the survivors were vigorous. The sample was determined as predominantly Crown, with probably an admixture of Royal. The field results indicated Crown (84% wilt).

1532—The first greenhouse test was indefinite (50% wilt), but the repeat test clearly indicated Crown (84% wilt). This result was borne out by the field test (99% wilt).

1982 and 1984—Two greenhouse tests indicated that these samples were mixtures of the two varieties (averages of 47 and 58% wilt, respectively). In both, the survivors were vigorous. The field determinations were recorded as Crown (63 and 69% wilt, respectively), but it would seem that these percentages of wilt in the field do indicate a probable admixture of Royal, so that even in these two cases the greenhouse and field results are in accord.

2523—Two greenhouse tests averaged 26% wilt, with surviving plants vigorous. This indicated Royal with probably a slight admixture of Crown. The field inference was "Royal?" (33% wilt). The greenhouse determination is probably correct.

TABLE 1.—COMPARATIVE RESPONSE OF UNDETERMINED CROWN AND ROYAL SEED SAMPLES IN FLAX-SICK SOIL IN THE GREENHOUSE AND THE FIELD

Sample No.	Emergence		Wilt*		Variety indicated
	Greenhouse	Field	Greenhouse	Field	
	%	%	%	%	
Crown	98	78	87	99	
Royal	100	73	1	25	
565	80	68	75	89	C†
595	28	36	85	100	C
640	44	72	0	18	R†
641	52	62	77	100	C
701	52	67	7	17	R
703	60	67	13	22	R
751	60	73	73	100	C
927‡	100	83	56 (56)§	100	C
1008	60	72	7	19	R
1108	52	67	85	97	C
1306	56	56	85	82	C
1307	52	75	77	92	C
1309	60	79	13	24	R
1310‡	57	60	21 (76)	84	C
1312	96	84	17	16	R
1327	56	50	14	12	R
1388	80	87	70	100	C
1390	84	75	86	87	C
1397	76	82	84	90	C
1468	45	65	20	26	R
1532‡	43	56	50 (84)	99	C
1580	80	75	10	34	R
1656	30	62	86	73	C
1657	22	56	91	89	C
1717	50	59	8	16	R
1718	70	74	83	79	C
1734	34	61	0	16	R
1739	66	65	0	24	R
1740	62	77	0	14	R
1780	76	67	73	79	C
1982‡	48	71	46 (48)	63	C
1984‡	66	65	60 (55)	69	C
2007	76	74	78	100	C
2009	60	73	73	84	C
2212	70	76	8	25	R
2360	50	76	4	23	R
2468	60	76	13	24	R
2523‡	80	75	30 (22)	33	R
2700	50	78	76	97	C
2742	40	55	70	100	C
2775	58	67	72	100	C
2816	52	67	11	23	R
2924	56	80	4	26	R
3305	46	71	0	23	R
3306	40	71	95	97	C
3307	56	77	82	100	C
U. 1	54	61	4	8	R
U. 2	70	41	93	88	C
U. 3	42	67	76	97	C
U. 4	68	68	88	74	C
U. 5	50	59	0	15	R
U. 6	58	66	0	13	R
U. 7	42	77	76	80	C

* Includes all post-emergence killing.
† C, stands for Crown, and R, for Royal.
‡ Samples given special comment in text.
§ Figures in brackets are the results of a second test.

The scatter diagram in Figure 3 shows the relationship between the percentages of wilt in the greenhouse and in the field. Samples determined as Crown or as Royal form distinct, separate groupings, while samples which are probable mixtures of the two varieties take up intermediate positions.

The mean percentages of emergence and wilt of the 30 samples determined as Crown and the 23 determined as Royal in Table 1 are presented in Table 2.

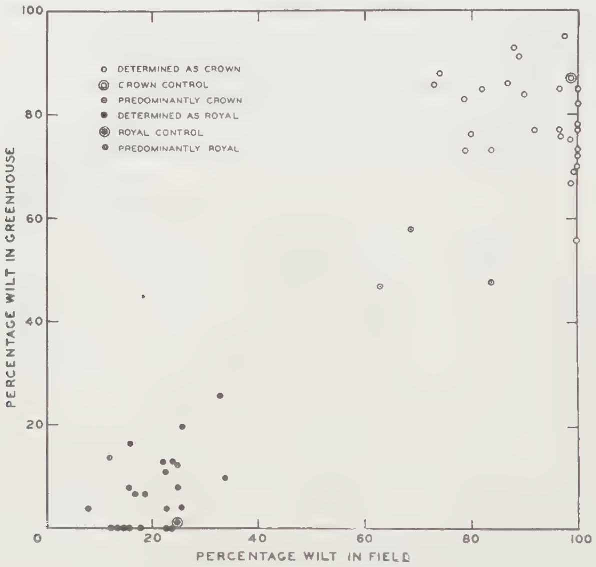

FIGURE 3. Shows the relationship between the percentages of wilt in the Crown and Royal flax samples in the greenhouse and in the field tests as given in Table 1.

TABLE 2.—A COMPARISON OF THE MEAN PERCENTAGES OF EMERGENCE AND WILT OF THE CROWN AND ROYAL SAMPLES AS DETERMINED IN TABLE 1.

Variety as determined	No. of samples	Emergence		Wilt	
		Greenhouse	Field	Greenhouse	Field
		%	%	%	%
Crown	30	57.8	67.2	76.2	90.0
Royal	23	58.3	69.6	7.8	20.2

With few exceptions the percentage of wilt in the field was higher than that in the greenhouse, the average being approximately 13 percentage points higher for both varieties. This may be due in part to the later date at which the survival counts were made in the field, but it in no way interfered with varietal determination. In every instance, the varietal determinations of the samples in the greenhouse agreed with those in the field. Those samples whose determinations were indefinite or about which some doubt existed from the greenhouse results are given special comment in the

text (see above). Some of these are doubtless mixtures of the two varieties, such as samples 1982 and 1984 which are very probably predominantly Crown with a small admixture of Royal.

Pre-emergence killing in the field was lower (10 percentage points) than in the greenhouse, but post-emergence mortality was higher (13 percentage points), for both varieties. That is, if the percentage mortality were based on the number of seeds sown, and not on the number of emerged seedlings as was done in these experiments, the greenhouse and the field percentages would approximate each other more closely. This alternative method would give higher mortality percentage values, since these would include all seeds which failed to germinate regardless of whether the failure were due to parasites or to mechanical injury. The procedure followed, however, is considered to give a more accurate representation of the data sought. The varietal determination of a given sample will be the same no matter which of the two procedures is used in calculating the percentage mortality. The generally drier conditions in the field, however, probably account for the greater emergence. The more heavily suberized endodermis and the difference in composition of cortical cells of the roots of flax seedlings grown in the field compared with seedlings grown in the greenhouse, as reported by Boyle (1), would hardly be factors influencing pre-emergence killing at this early stage. Flor (2), working in North Dakota, found no pre-emergence injury to flax in the field. That field germination of the flax samples was generally lower than the laboratory plate germination in our experiments, is considered as evidence that pre-emergence injury of flax did occur in the field, although the injury was less than in the flax-sick soil in the greenhouse.

The low germination of many of the samples was due mainly to seed-coat cracking, which averaged 38.3% for 20 random samples; and to frost injury, which was slight to severe in 21% of the samples. Forty-two per cent of the samples showed trace to moderate infection with the stem-break and browning organism (*Polyspora Lini* Laff). Of the 58 samples of Crown, 38% were infected, and of the 38 samples of Royal, 47% were infected. These infections possibly reduced germination slightly in a few instances.

Fifteen other undetermined samples were grown in the field in an area only lightly infested with the damping-off and wilt-producing organisms. The procedure was the same as in the heavily infested wilt nursery, except that no counts were taken; instead, varietal identity was recorded by visual examination only and the results compared later with the greenhouse determinations. Here also the field and greenhouse varietal determinations agreed in every instance.

TABLE 3.—A COMPARISON OF THE MEAN PERCENTAGES OF EMERGENCE AND WILT OF 96 FARM SEED STOCKS OF CROWN AND ROYAL AS DETERMINED IN GREENHOUSE TESTS.

Variety as determined	No. of samples	Emergence	Wilt
		%	%
Crown	58	58.2	81.1
Royal	38	60.3	6.0

Table 3 gives the mean percentages of emergence and wilt in the greenhouse tests in all of the 96 samples, 58 of which were determined as Crown and 38 asRoyal. Since the detailed results suggest that 5 of the samples are mixtures of the two varieties, it is reasonable to infer that the mean percentages of wilt in Tables 2 and 3 are slightly lower in "Crown" and slightly higher in "Royal" than they would be if there were no admixtures.

DISCUSSION

The results are very encouraging and strongly suggest that the greenhouse method of determining the identity of Crown and Royal seed samples in flax-sick soil is a reliable one which may be used as a quick service for producers in place of the longer field method. The moderate to fairly high resistance of Royal to the various species and strains of damping-off, blighting and wilting fungi in these soils may possibly not be maintained in other flax-growing areas where climate, soil, and parasitic fungi may be different. Indeed, this contention seems to be borne out by slightly higher percentages of wilt on Royal reported from Eastern Canada and the northern United States than are obtained under our conditions. The testing of the efficacy of the method with wilt-infested soils from other regions at once suggested itself. Paper II of this series presents a preliminary study of the comparative differences in mortality response of Crown and Royal flax in flax-sick soil from Ottawa and from Saskatoon. The greenhouse method, however, should find application as a temporary measure to meet a special situation in Saskatchewan.

There were indications that 5 of the 96 samples tested were mixtures of Crown and Royal. Four of these are shown in Figure 3 in an intermediate position between the distinct, separate groupings of samples determined as pure Crown or as pure Royal. The other mixed sample was one of the 15 grown in the lightly infested area adjoining the wilt nursery on which observational data only were secured. It is not included in Figure 3. Since it is visually impossible to separate the seed of the two varieties and thus determine the purity in the seed laboratory, and since, because of its high susceptibility to wilt it is desirable to discontinue growing Crown, great care should be taken by producers to prevent Royal stocks from becoming contaminated with admixtures of Crown. That mixing can occur all too easily is evidenced by the relatively large number of samples of Crown and Royal in which admixtures of Bison or Redwing seeds are found.

Apparent admixtures of Royal in farm seed stocks of Crown may possibly have been brought about by a gradual increase in the wilt resistance of Crown grown repeatedly on land infested with the wilt organism. Cases in which this may have occurred are considered to be rare. On the other hand, apparent admixtures of Crown in seed stocks of Royal are most probably due to actual mixing, as Royal seed has been commercially available for only three years.

SUMMARY

It has been generally recommended that the growing of Crown flax, because of its high susceptibility to *Fusarium* wilt, be discontinued in

Saskatchewan and that it be replaced by the moderately wilt-resistant variety, Royal. As it is not possible to separate the seed of these two varieties visually in the laboratory, a need arose for a method of ascertaining the identity of undetermined seed stocks of these varieties.

A comparison was made of the percentages of wilt (total plant mortality) in 96 such samples grown in flax-sick soil in the greenhouse and 68 samples in both the greenhouse and the field with the University strains of Crown and Royal as controls. In all cases the varietal determinations in the greenhouse and in the field were in agreement. The results suggest that the greenhouse method can be used as a temporary measure to meet a special situation in Saskatchewan without further implementation by a field test.

ACKNOWLEDGMENTS

Grateful acknowledgment is given to Mr. T. W. L. Burke, Dominion Seed Laboratory, Plant Products Division, Saskatoon, for his willing cooperation and for supplying laboratory help from time to time; and to Dr. J. B. Harrington for space facilities in the wilt nursery, and for many other courtesies.

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STUDIES ON CROWN AND ROYAL FLAX IN FLAX-SICK SOIL

II. COMPARATIVE MORTALITY RESPONSE OF CROWN AND ROYAL FLAX IN TWO DIFFERENT FLAX-SICK SOILS[1]

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Slightly higher percentages of *Fusarium* wilt have been reported on Royal flax grown in wilt nurseries in Eastern Canada, and the northern United States, than have been recorded in the wilt nursery at the University of Saskatchewan, Saskatoon, over a period of years. It is highly probable that the major part of the plant mortality in such soils is due to *Fusarium Lini* Bolley (1), but under certain conditions other pathogenic forms such as *Rhizoctonia Solani* Kühn, *Pythium de Baryanum* Hesse (2), and other *Fusarium* spp., undoubtedly are contributing causes. In a preliminary attempt to check on these differences, a 100-lb. sample of flax-sick soil was obtained from Mr. W. G. McGregor, Central Experimental Farm, Ottawa, at the suggestion of Dr. J. B. Harrington of the Field Husbandry Department, early in the spring of 1943. At the same time fresh samples were collected from the old wilt nursery (on block 505) in which Royal was developed as a wilt-resistant selection from the wilt-susceptible Crown, and from the new 4-year-old nursery (on block 1203). The Ottawa soil was a light loam with pH 7.1 and the Saskatoon soils were silty clay loams with pH 6.7 (block 1203) and pH 6.8 (block 505). Two flats 12 by 18 by 4 inches deep, were filled with each soil sample making a total of 6 flats; these were then sown with 2 rows of Crown and 2 of Royal (Figure 1) and kept in a lightly shaded greenhouse. The temperatures were cool to moderate during the first experiment, late May to July, 1943, and moderate to hot during the second experiment, July to August. The seed consisted of the University strains of these varieties and a first prize sample of Royal from Rosetown, Sask., and a sample of Crown from Kerrobert, Sask. All samples were evidently of high purity as there were no significant differences in percentage wilt between samples of the same variety. To facilitate the condensation of data the two samples of each variety were regarded as one. The combined results of the two experiments are given in Table 1. In series I a total of 180 seeds was sown in each soil, but in series II, the number of seeds was not counted. Emergence counts were made about 2 weeks after sowing, the first count of survived seedlings about 2 to 3 weeks later, depending on temperature conditions, and a second survival count after another 10 to 14 days. In both series the percentage of wilt is based on the number of emerged seedlings.

Royal flax shows only moderate survival (fair wilt, 36%) in the Ottawa soil, while in the Saskatoon soils it shows high survival (slight wilt, 10 to 12%). Crown shows fair survival (66% wilt) in the Ottawa soil, and poor survival (97 to 99% wilt) in the Saskatoon soils (Figure 1). This indicates

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[2] Professor of Plant Pathology.

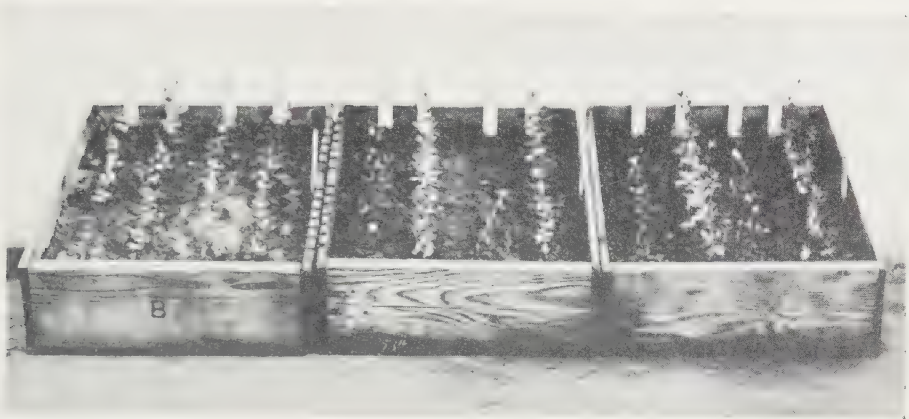

FIGURE 1. Alternate rows of Crown and Royal flax in flax-sick soils; Ottawa soil in flat at left, Saskatoon soil from block 505 at centre, and Saskatoon soil from block 1203 at right. Crown shows less susceptibility to wilt in the Ottawa soil than in the Saskatoon soils, while Royal shows more susceptibility to wilt in the Ottawa soil than in the Saskatoon soils.

TABLE 1.—COMPARATIVE RESPONSES OF CROWN AND ROYAL FLAX TO WILT IN DIFFERENT WILT-INFESTED SOILS IN THE GREENHOUSE*

Variety	Ottawa soil					Saskatoon soil—Block 1203					Saskatoon soil—Block 505				
	Emergence	Survival counts		Wilt		Emergence	Survival counts		Wilt		Emergence	Survival counts		Wilt	
		1	2	no.	%		1	2	no.	%		1	2	no.	%
Series I†															
Crown	166	73	48	118	71.1	153	25	7	146	95.4	149	70	3	146	98 0
Royal	166	116	110	56	33.7	157	153	144	13	8.3	148	131	129	19	12.8
Series II															
Crown	244	144	90	154	63.1	242	85	6	236	97.5	275	108	9	266	96.7
Royal	220	161	137	83	37.7	224	205	198	26	11.6	239	217	212	27	11.3
Total, Series I and II															
Crown	410	217	138	272	66.3	395	110	13	382	99.3	424	178	12	412	97.1
Royal	386	277	247	139	36.0	381	358	342	39	10.2	387	348	341	46	11.9

* Each series represents the combined results of two experiments.
† 180 seeds were sown in each soil in series I.

that the strains or species of pathogenic fungi in the Ottawa soil are more virulent on Royal flax and less virulent on Crown than the strains or species in the Saskatoon soils. In all the flax-sick soils, Crown shows a definite progressive plant mortality up to the final survival count; Royal, however, shows a moderately progressive mortality in the Ottawa soil, but there is only a slight increase in mortality after the first survival count in the Saskatoon soils. This possibly suggests that the killing of Royal in the

early seedling stage in the Saskatoon soils is mainly of the damping-off type (*Pythium* spp. and *Rhizoctonia Solani*), while in the Ottawa soil some other fungus is responsible for the later killing of Royal.

Isolation work from diseased and dead seedlings grown in these respective soils in order to ascertain the causal organisms involved is now in progress.

There was a slight increase in the mortality of seedlings of Crown and Royal in the second experiment in both series I and series II in the Ottawa soil. In the two experiments there were no significant differences in seedling mortality in the Saskatoon soils.

The foregoing findings in general support the contention, already well known in plant pathology and plant breeding, that a plant variety, resistant to a given disease in one region, may not necessarily be as resistant to the same disease in another region.

SUMMARY

The highly wilt-susceptible flax variety Crown and the moderately wilt-resistant variety Royal were grown in the greenhouse in wilt-infested soil from Ottawa, Ontario, and from Saskatoon, Saskatchewan. The results brought out the interesting fact that Crown is relatively *less* susceptible to wilt as expressed in post-emergence percentage mortality, in the Ottawa wilt-infested soil (66%) than in the Saskatoon wilt-infested soil (97%); while Royal is relatively *more* susceptible to wilt in the Ottawa wilt-infested soil (36%) than in the Saskatoon wilt-infested soil (12%), under the conditions of the experiments.

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PASTURE STUDIES No. XXV.

PASTURE SUCCESSION IN THE EASTERN TOWNSHIPS OF QUEBEC[1]

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From the beginning of pasture research in Quebec an ecological survey has been utilized to obtain the fundamental knowledge essential to the development of a rational program of grassland betterment. A background of sward studies can now be referred to in the arrangement and strategic placing of field experiments and in making recommendations. Sufficient information has accumulated during these studies to permit the present discussion of a subject of general pasture interest, succession.

All of the data included here emanates from observations in the Eastern Townships, Appalachian district of southern Quebec, which have served as a testing ground for much of the ecological theory of the provincial pasture surveys. One of the most interesting problems investigated in the Townships has been that of accounting for the seemingly hopelessly confused distribution of swards. Frequently within a restricted area and on the same soil type, all the main swards and intergrades can be seen: a Kentucky blue-white clover pasture may lie across the fence from a red top or poverty grass pasture, while on the next field, red fescue shows typical dominancy. An attempt to resolve this problem was begun in 1941 when swards were studied in relation to various factors. Possibility that the striking soil variation might account for some of the sward variation was not overlooked, and soil maps prepared by Cann and Lajoie (1) showing the different soil types were utilized throughout.

METHODS

As a first step, major soil types were selected and profiles studied in collaboration with soil surveyors. This was very necessary, for soil maps were of a reconnaissance order and at no given point was it possible to be sure of the type without checking. Variation in the type and discontinuous distribution of the soils added to the difficulties. Familiarity with the different soils was obtained only after many profiles had been seen.

Numerous pastures were visited on these major types. The nature and extent of the true sward of grasses and associated weeds were understood and recorded first. Many fields had a remarkably uniform flora throughout, but in others several important sward types would be present suggesting that the sward was undergoing a transition. In these cases all the sward types would be listed and the relative importance of each estimated. The other important groups, such as plants about droppings, plants on hummocks, plants invading, where interesting or informative as

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to some particular point, were recorded separately and with source clearly indicated. This is quite a simple procedure, but it suggests certain precautions. There is a tendency for species to be listed indiscriminately and perhaps too thoroughly in ecological pasture work. A lengthy plant list is frequently regarded as an end in itself, resulting in a garbled and meaningless record not capable of intelligent analysis.

Not only was the sward cover read and the soil type verified by digging but the field history was ascertained by enquiry or observation of the field and soil profile. Under history were included notes on former ploughing and cropping, age of the pasture, and fertilizer status.

General Observations

Reference to the condition of the drainage and history of the field is usually sufficient to furnish an explanation for the presence or absence of a sward at any particular pasture site in the Townships. Apparently nothing can be added to the explanation by introducing the soil type concept. Any one of the soil types may bear numerous examples of all the swards except poverty grass, and any one of the swards with the same exception may be found on all the soil types. The varying parent materials permitting the extensive differentiation and mapping of soils seem to have had little influence on the pasture pattern. Drainage which has been utilized as a secondary factor to source of parent material in the classification of soils is of importance, however, in sward distribution. For the present purpose then, it will be sufficient to group the numerous soil types into two divisions, well- and ill-drained.

Field history may have even more importance than drainage in sward distribution. It might be contended that such a factor in effecting changes in flora is also represented by changes in the soil. This may well be perfectly true, yet such soil changes are not of an order sufficient to alter the soil type. Therefore, the only conclusion must be that the reconnaissance system of soil mapping does not offer any explanation of the swards except in so far as drainage is concerned.

The effect of drainage and field history in determining swards may be best illustrated in a discussion on succession. Swards change with length of time under pasture and the succession concept must be introduced in any attempt at explaining cover. Certain schemes based on a simple succession have been advanced in recent years and should be considered.

New York State Pasture Succession—Cooper (3)

(*a*) Kentucky blue and white clover.
(*b*) Kentucky blue, bent grasses, and white clover.
(*c*) Bent grasses and white clover.
(*d*) Bent grasses, sweet vernal grass, and white clover.
(*e*) Sweet vernal grass.
(*f*) Sweet vernal grass and poverty grass.
(*g*) Poverty grass.
(*h*) Herbaceous weeds, shrubs, and trees.

Eastern Townships Pasture Succession—Frankton (5)

(*a*) Kentucky blue and white clover.
(*b*) Kentucky blue, bent grass *Agrostis alba*, and white clover.
(*c*) Bent grass and white clover, or bent grass and Kentucky blue.
(*d*) Bent grass.
(*e*) Red fescue and bent grass.
(*f*) Red fescue.
(*g*) Red fescue and poverty grass.
(*h*) Poverty grass.

Differences between the two arrangements depend largely on differences of flora in the two regions. Under Quebec conditions, sweet vernal grass (*Anthoxantum odoratum*) is infrequent, and, in no sense, part of the succession. Its place is taken by red fescue. The last stage, according to Cooper (2), is "herbaceous weeds, shrubs, and trees", but probably this should not be thought of as the termination of a depletion line but as the type of vegetation that will appear at any time grazing is reduced beyond a certain limit, no matter what the fertility level.

These cycles are, undoubtedly, essentially true although based on superficial observation of swards. No such simple concepts of succession are tenable, however, if drainage and the various details of history are to have full weight, and further subdivision is needed. The pasture succession to be advanced will attempt to introduce a more completely descriptive scheme. Complexity of the problem demands that any explanations suggested for sward changes should be regarded as hypotheses to aid in future investigation rather than as absolute truths.

The varying agricultural practices and land conditions on which these subdivisions depend will require some discussion. A history of ploughing preceding establishment has a marked influence on the immediately succeeding pasture stand and the subsequent cycle. Ploughing and cultivation have hastened deterioration in Township pastures, while old pastures on virgin soils still show a remarkably good cover. Colby (2) has explored the American pasture literature from the earliest writings and his findings are much the same: "because it was observed years later that pastures which were established on cultivated land deteriorated much more rapidly than those which were laid down immediately after the removal of the forest trees. Many of these original pasture areas produced many successive crops of grass without the aid of soils amendments before exhibiting any signs of exhaustion." and, "It is not surprising either to find that evidence of pasture deterioration is first found in the early settled portions of the State . . . . . ."

Drainage differences are to be expected in this hilly region. The upland soils usually evidence by colour, brownish or brownish-red, the complete oxidation dependent on good drainage. Ill-drained soils in the lower lying places with poor soil aeration are mottled and darker, usually blackish or grayish. Pasture herbage is evidently not insensitive to the factors promoting differences between the two soil moisture groups.

The successions will be introduced under:

A. Pastures on sites that have never been ploughed.

B. Pastures on sites at some time ploughed and cropped.

(1) Ill-drained.

(2) Well-drained.

Examples are given of the various pastures found at different age levels for each of these groups. It should be realized that only a few samples are possible, that much variation exists, but that the illustrations chosen are intended to depict the true trend. Only fields under the influence of the grazing animal are included and the very few fertilized fields have been omitted.

Pastures on Sites That Have Never Been Ploughed

In the Townships, young pastures on virgin soils and with the biotic factor acting to some degree are invariably under a cover of Kentucky blue-white clover. This is a small scale repetition of what followed on the original introduction of the European pasture plants to northeastern America for both Kentucky blue and white clover were outstandingly aggressive. According to Colby (2), who has reviewed the early literature, white clover became very quickly naturalized and much more so than the grasses.

With the increasing age of pasture, clover decreases and Kentucky blue makes a corresponding gain. Red top is always present to some degree from the beginning and advances steadily. Older fields are usually dominated by this bent, although there are some exceptional fields over a half century in pasture with as much as 70% Kentucky blue and white clover.

Absence of red fescue from these virgin soils in a region where the grass is abundant is one of the most noteworthy features of the first 30 or 40 years. On the uncultivated, ill-drained soils there is little evidence of the grass penetrating on even older fields. To a considerable extent this is also true of the well-drained, yet exceptions occur, and it is highly probable that, with time red fescue would dominate. Large areas of well-drained fields in Shefford and Richmond Counties, evidently too stony for cultivation and of great age, are strongly red fescue. Of course, on abrupt slopes, even on unturned pastures, poverty grass becomes the dominant.

Entrance of Kentucky blue-white clover into the soil exposed by forest removal may well depend on the grazing animal. Dore and Raymond (4) have investigated the seed content of manures from pastures, and find that seeds of these plants are present in high percentages. But red top seed is represented in manure to an even greater degree. Evidently red top is kept in abeyance until some change in conditions, not necessarily of fertility, reduces the original competitive advantage of Kentucky blue-white clover.

The conditions for red fescue succession are described later.

The points discussed can be illustrated by typical examples of swards (Tables 1 and 2). Only the abundant species are mentioned. Red fescue occurred on none of these fields. In both tables all pastures show presence of Kentucky blue and white clover. Table 2 suggests the increasing importance of red top with age.

TABLE 1.—JUVENILE SWARDS—KENTUCKY BLUE-WHITE CLOVER

Survey	146A	146B	189	199	99	53
Soil type	*Greensboro		Coaticook	Greensboro	Calais	Dufferin
Age	5–10 yrs.	15–20 yrs.	5–yrs.	5–10 yrs.	8 yrs.	5 yrs.
	Well-drained		Ill-drained	Well-drained	Ill-drained	Ill-drained
	%	%	%	%	%	%
White clover	40	15	30	20	20	50
Kb	10	40	40	25	15	22
Red top	—	10	—	15	5	3
Timothy	—	—	—	10	—	—
Weeds, bare, stumps	50	35	30	30	65	35

TABLE 2.—OLD SWARDS—RED TOP

Survey	51B	186B	Line 57	6	54	55
Soil type	Berkshire	Greensboro	Dufferin	Magog	Dufferin	Dufferin
Age	25 yrs.	20 yrs.	60 yrs.	50 yrs.	15–20 yrs.	20–25 yrs.
	Well-drained	Well-drained	Ill-drained	Ill-drained	Ill-drained	Ill-drained
	%	%	%	%	%	%
White clover	2	7	7	3	15	5
Kb	15	3	7	4	20	10
Red top	45	50	50	66	15	35
Phleum	—	—	3	2	—	—
Weeds, bare, stumps	38	40	33	25	50	50

* Complete names and descriptions of the soil types will be found in *Soil Survey of Stanstead, Richmond, Sherbrooke, and Compton Counties*, by D. B. Cann and P. Lajoie (1).

Pastures on Sites at Some Time Ploughed and Cropped

A. Ill-drained

Effect of cultivation on the subsequent pasture flora is quite marked on ill-drained sites. The Kentucky blue-white clover sward of the unploughed fields does not appear and, in the first pasture years after hay, red top is the important grass. Most distinctive feature, and one in complete contrast to the unploughed, ill-drained, is the eventual appearance of red fescue or occasionally brown top. On unusually ill-drained sites, however, red top may remain. Poverty grass never occurs on these ill-drained soils.

Examples of the red fescue type are shown in Table 3.

TABLE 3.—RED FESCUE ON ILL-DRAINED FIELDS OF INTERMEDIATE AGE

Survey	105	10		335A	339	341	36	324A	324B
Soil type	Dufferin	Dufferin		Calais	Dufferin	Dufferin	Magog	Dufferin	Dufferin
Age	20 yrs.	25 yrs. June	October	14 yrs.	30 yrs.	35 yrs.	15 yrs.	30 yrs. Ploughed	25 yrs. Unploughed
	%	%	%	%	%	%	%	%	%
White clover	2	Present	3	2	3	2	5	2	1
Kb	—	Rare	2	Rare	—	—	—	Present	5
Red top	8	Present	Present	15	4	5	2	3	60
Red fescue	60	5	65	46	73	77	60	75	—
Brown top	—	—	—	—	—	—	15	—	—
Timothy	—	—	—	—	6	5	15	—	4
Weeds	10	—	5	10	2	3	3	5	—
Sedges	—	95	5	—	—	—	—	—	—
Bare and moss	20	—	15	25	12	8	18	15	10
Hummocks and cedar	—	—	—	—	—	—	—	—	20

Benefits of intensive grazing on these wetter soils when cultivation has evened the surface are shown in Survey 10. An astounding change in flora has followed the dry summer of 1941 and hard grazing. The distinctive floras of the ploughed and unploughed are particularly well instanced by Survey 324. Bent grasses dominate on the unploughed B, and form a thick ungrazed mat, while A is well-grazed and has a red fescue cover.

Red top may be more abundant in the first years after hay, though sometimes red fescue appears very early when the field has been long in hay. Subsequently, where grazing is intensive enough and the soil not excessively wet, red fescue forms the swards as contrasted to the continuing red top fields of the unploughed. Cultivation probably makes the habitat more suitable for red fescue by permitting better aeration and a more uniform surface, thus eliminating the natural depressions in which red top is more likely to succeed or survive.

Pastures on Sites at Some Time Ploughed and Cropped

B. Well-drained.

The most abundant group of pastures is that on fields that have at some time been ploughed and cropped. Red top is the dominant on young fields of this class.

TABLE 4.—JUVENILE SWARDS—RED TOP

Survey	44	29	102	82
Soil type	Greensboro	Greensboro	Greensboro	Sherbrooke
Age	3 – 8 yrs.	2 yrs.	15 yrs.	15 – 20 yrs.
	%	%	%	%
Kb	Present	Rare	Rare	5
White clover	Present	10	3–4	15
Red top	45	35	55	40
Red fescue	—	—	Occ.	5
Timothy	Present	35	1–2	10
Bare–weedy	55	20	40	25

The early dominance of red top that follows the hay years is soon disturbed for it is a sociable grass, not tufted and rather widely-spaced, and may be easily invaded by red fescue or brown top. Typical patches of red fescue coming into these comparatively new fields have undoubtedly been observed by all pasture workers. Lack of sociability and perhaps more vigorous and early growth under pasture conditions enables the fescue eventually to master the whole terrain, but as field readings show, never completely dispossessing the bent.

Length of time that the sward will be fescue dominant is dependent on the level of fertility, when pasturing began—slope has an effect— but 20-40 years is a fair estimate. These fields are frequently of good size, 20 or more acres, and grazing is remarkably close. Palatability of the grass is clearly greater than that of the bents which are often permitted to head while fescue in the same field is grazed closely. Red fescue lacks sociability and under the close grazing, fills the available space with its shoots and the plant has the highest percentage of ground cover of any of our grasses.

There has been some opportunity to observe the entrance of red fescue more directly. One field (red top—15 years in pasture) in the short period 1939–1942 had an increase in red fescue from a single patch to 20%. Dry seasons might speed the process and two of the years concerned were exceptionally dry. Brown top is locally abundant, and in these regions may frequently form the sward at this stage or earlier. This free-seeding grass appears to be present on younger fields than red fescue. The cattle permit brown top to flower and much more seed must be available in nature. Soil samples examined in the winter of 1941-1942 from below a brown top sward contained 13–15 million seeds to the acre.

TABLE 5.—FIELDS OF INTERMEDIATE AGE—RED FESCUE AND BROWN TOP

Survey	40		250	157A	192	155A	278
Soil type	Greensboro		Berkshire	Sherbrooke	Sheldon	Greensboro shallow	Berkshire
Age	A 15 yrs.	B 25 yrs.	30 yrs.	20 yrs.	6 yrs.	25 yrs.	25 yrs.
	%	%	%	%	%	%	%
Kb	Present	Present	Present	Present	5	—	1
Red fescue	40	45	70	62	5	65	80
Red top	30	5	5	5	5	5	1
Brown top	—	—	—	—	65	—	—
Poverty grass	—	25	—	—	—	Present	—
White clover	—	—	5	3	10	7	—
Weeds—bare	30	25	20	30	10	23	18

Explanation for the tardiness of red fescue entrance might be sought in distribution of seed. Dore and Raymond (4) found that the plant was practically unrepresented in manure samples. Incidentally, the seed is the heaviest by far of the pasture grass seeds, thus reducing motility. Seed content studies in 1941 (unpublished) of soil samples from below red fescue swards revealed that seed was practically non-existent. The plant is

grazed so hard that the amount of seed produced must be comparatively small. The patches, generally circular, of this grass in the early stages of its entrance suggest that spread is largely a vegetative matter. This is one phase of the cycle where it would be rash to state that reduced fertility engendered a change of sward. Differences in dissemination and production of seeds seem to be a more reasonable explanation.

Even when seeded, red fescue attains its maximum performance quite late. In Germany (7) a seeding planned to give: *Trifolium repens* 40%; *Lolium perenne* 25%; *Poa pratensis* 17%; *Festuca rubra* 18%; resulted in a very different stand. After two years *Lolium perenne* occupied 57% of the terrain and the other grasses smaller areas than expected. *Poa pratensis* dominated a few years later, giving way eventually in the ninth year to *Festuca rubra.* In the development of a pasture sward without seeding, *Festuca* might be expected to make even slower ingress for the reasons stated in the preceding paragraph.

The end of the pasture cycle on cultivated fields finds poverty grass the dominant (Table 6). These fields are generally old—50 years or more, but may be much younger. At the final stage of the cycle it is noteworthy that red top which has persisted throughout the red fescue period, still remains, although often red fescue has been eliminated entirely. Survey 300 is a good example of the transition stage between red fescue and poverty grass. Rather more than half of the field is under poverty grass.

Table 6.—Old fields—Poverty grass

Survey	300		199	95B	246
Soil type	Greensboro		Greensboro	Greensboro	Berkshire
Age	(Red fescue) 35 yr.	(Poverty grass) 35 yr.	60 yr.	30 yr.	50 yr.
	%	%	%	%	%
Red fescue	60	18	—	—	—
Poverty grass	2	38	65	70	75
Other grasses and clover	7	3	—	5	1
Weeds	10	10	10	Few	9
Bare and moss	21	31	25	25	15

Undoubtedly, severe cropping practice prior to pasturing accelerates the pace of the cycle. In Stanstead County, the old-settled districts, exemplified by Brown's Hill, Dufferin Heights and East Hatley, are marked by a greater proportion of poverty grass pastures than in the County as a whole. The moraine ridges were cleared early following the pioneer custom of removing the hardwood to make potash for ready funds. Soil conditions were undoubtedly more amenable than in the valleys, as was air drainage, and cultivation proceeded actively. Many of the fields now under poverty grass were probably placed under pasture only when further seeding of hay or grain seemed profitless. Amendments were not employed to any great degree, and the years of cultivation would exhaust the soil far more than pasturing. Poverty grass has been recorded from only a

very few uncultivated fields. Considering the age of some unbroken fields, it will be a long time before the swards pass through the closing stages of the succession.

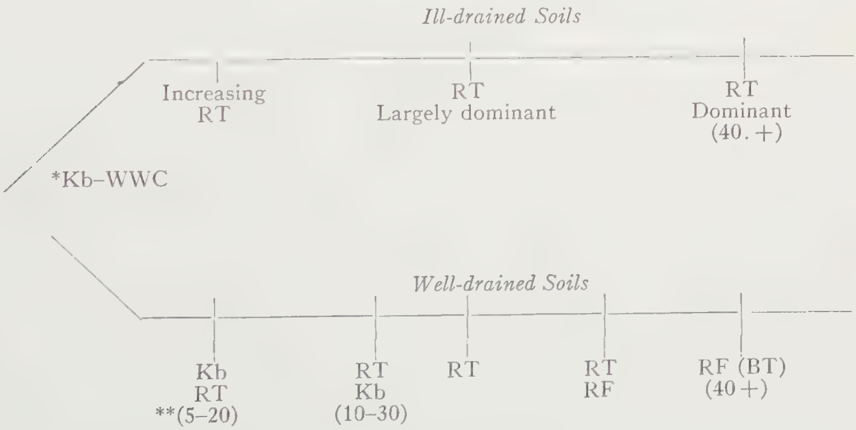
DISCUSSION

Attention has been drawn to the sward complexity in pastures of the Eastern Townships. Widely different swards, such as Kentucky blue-white clover, red top, red fescue and poverty grass, may be seen on the same soil type and in adjacent fields. Investigation has revealed that, although environmental factors, climatic conditions and soil type, may be similar, differences exist in field histories and drainage.

When many such instances have been studied, certain generalities appear. Kentucky blue-white clover precedes all other swards on the new fields that have never been ploughed. This is true of all types, both ill-and well-drained. Red top follows the rich clover sward though eventually the unsociable, yet gregarious, red fescue or brown top take over. On the oldest fields, particularly when cultivation has preceded pasturing, poverty grass becomes the dominant.

Cultivation has a marked effect on subsequent pasture swards. Edaphic factors have changed; aeration in the ill-drained soils has been bettered, the fields are smoother, available minerals and organic matter are reduced. Ill-drained soils, in permanent pasture for several years have a cover of red fescue or brown top on fields that have, at some time, been ploughed, while virgin soils of the same age are under red top. Well-drained soils soon run out to poverty grass after cultivation has exhausted fertility resources, but far better swards remain on the unturned soils. These concepts have been incorporated in the following diagrams of the hypothetical pasture cycles.

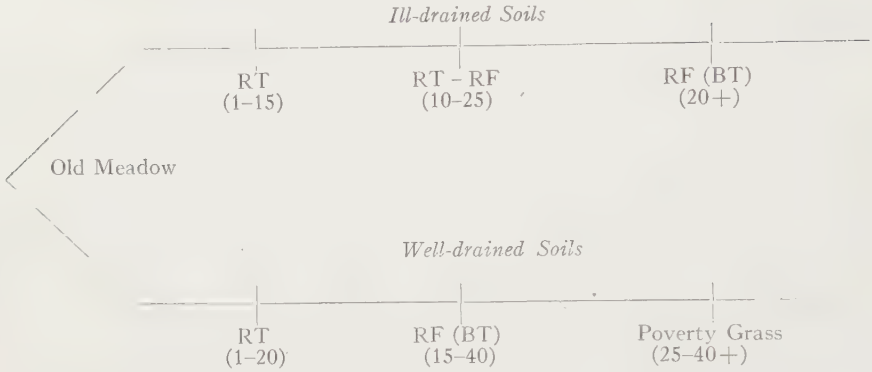
Pastures on sites that have never been ploughed:



*Kb = Kentucky blue
WWC = Wild white clover
RT = Red top
RF = Red fescue
BT = Brown top

**These figures represent years from the beginning of pasturing. In this scheme it is suggested that the sward concerned, Kb–RT, will appear at the earliest, after 5 years, and will be succeeded by RT–Kb not later than 20 years after the establishment of the pasture.

Pastures on sites at some time ploughed and seeded:



The question regarding the correlation of edaphic changes with these sward changes, remains. Cooper (1932) exploded the idea that increasing acidity was linked to pasture deterioration. Determination of pH from many samples of soils from below a wide range of sward types revealed no significant differences. In Stanstead, on this survey, poverty grass was seen growing quite actively on limy ridges.

Changes in pasture cover in the succession are usually supposed to follow on changes in the fertility level. Cooper concludes that exchangeable cations both in quantity and quality are of greater significance in influencing distribution of pasture plants than the hydrogen ion. Other workers agree and Robinson (1937) finds, "the primary chemical properties limiting the percentage of Kentucky blue and white clover in the pasture studies are percentage base saturation and available phosphorus."

The trend is in the direction of soil depletion on most pasturelands today, so that the succession is normally a retrogression from the agricultural viewpoint. However, it is accepted that the cycle is reversible and that the cover can be graded upwards by proper manuring and management without the use of seeds. This concept may, in the main, be correct, but for some phases, perhaps too much has been assumed. It has been observed in the Townships that fertilized red fescue swards remain largely as before, though higher yielding and perhaps even more palatable. Poverty grass cannot always be made to yield ground by mineral application. According to Frankton and Raymond (6), there are probably 40 square miles of poverty grass pasture in Stanstead County (430 square miles area) that would not respond.

Those writers who stress the fertility cycle, omit all reference to a factor which has been responsible for much of the deterioration: former cultivation. Effects of turning are manifold. Not only are the mineral elements depleted, but destruction of the organic matter accumulated under the original forest is hastened. Without reference to the laboratory, the observer easily notes that poverty grass soils are of poor structure, probably dependent on lack of properly decomposed organic material. The soil seems to be of single grain structure and difficult to wet. In contrast, the unploughed ground on which Kentucky blue-white clover flourish is rich in organic matter.

A further point should be emphasized. Pasture succession is usually considered as dependent on fertility changes. This may, in part, be fallacious. The red top to red fescue phase is not necessarily governed by fertility so much as by seed, and propagation factors. Red fescue seed, for various reasons, appears to be far less abundant in nature than red top or Kentucky blue seed, and accordingly, is more tardily introduced into pasture fields where it is largely confined to a vegetative extension.

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DOWNY MILDEW DISEASE OF CAULIFLOWER SEED PLANTS[1]

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Downey mildew (*Peronospora Brassicae* Gäum.) is a common parasite of cruciferous plants, but it has not been considered of much economic importance except in seedlings and in cabbage intended for shipment and storage. Recently an interesting phase of this disease was observed in British Columbia, where numerous cauliflower plants of the Snowball variety were made almost worthless for seed production owing to infection of the curd. Infection of the seedlings in cold frames and of the foliage of plants grown in the field has been observed during previous years in many localities. This year, a systemic type of infection involving the main stems and the curd was found in numerous plants where most of the curd parts were stunted, having failed to elongate into normal inflorescences (Figure 1). This stunting of the curd is somewhat similar to that associated with systemic downy mildew infection of terminal and lateral shoots in other hosts such as hops and legumes.

A constant symptom of this type of infection is a dark purple discoloration of the surface of the stems of the curd, which often appears in broad longitudinal streaks. Affected tissues were slightly shrunken, and conidiophores and conidia were usually present on the infected stems and leaflets. The internal tissues were also discoloured (Figure 1), this discoloration appearing as dark grey necrotic specks and areas throughout the tissues. This has been found in the main stems as well as in the stems of the curd. When infected tissues of the main stems and the curd were examined microscopically, mycelium and dichotomous haustoria of the downy mildew organism were found in the parenchyma and pith. The lobed haustoria were very prevalent within the cells, and were similar to those found by Gardner (1) in turnip roots.

Ramsey (2) who reported the disease on cabbage in storage, claimed that considerable loss was occasioned by bacterial soft rot and Alternaria rot following the infection by Peronospora.

In the Pacific Coast areas of British Columbia where cauliflowers are grown for seed, losses due to curd rot caused by various factors are often very considerable. This usually occurs when the curd is well developed, but before the floral parts begin to elongate. After the plants have passed this stage, the growers claim that the critical period for curd rot is over.

In order to test the pathogenicity of the downy mildew on the curd, a few small cauliflower plants were inoculated outdoors in October. This was done by placing leaves of cabbage seedlings bearing conidia of the downy mildew, both on the surface and among the inner parts of the curd. A few plants were set aside as checks. All the plants were watered periodically so as to insure ample moisture for spore germination.

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After approximately three weeks, the surface of the curd of the inoculated plants assumed a dirty white to a brown colour, while the colours of the surface and of the internal tissues of the curd stems were dark purple and dark grey respectively, like those observed in the field. The mycelium of the fungus was found in the terminal tissues and in the stems of the curd.

FIGURE 1. A longitudinal section through the main stem and curd of a cauliflower seed plant showing stunting of the floral parts and discoloration of the stem tissue induced by *Peronospora Brassicae* Gäum., with a normally developed shoot on the left.

In about 6 weeks after inoculation, the infected curd was shrivelled, stunted and brown in colour. Under the prevailing environmental conditions the fungus seemed to have a drying effect on the tissues. By this time, secondary organisms were present on the terminal parts of the infected curd. The curd of the check plants was white and firm and of normal appearance. When the first symptoms of browning appeared, it was noticed that the

curd remained slightly moist after spraying with water, while the water particles would not adhere readily to the surface of the curd of the check plants. The former condition should favour the germination and development of secondary organisms.

Insect pests such as flea beetles, thrips and aphids are usually prevalent on seed plants in the field. In several fields inspected, flea beetles were causing lesions on the curd as well as on the foliage, thus facilitating the entry of the downy mildew and other organisms. Some of these insects undoubtedly act as spore carriers.

Weber (3) claims that the control of downy mildew on cabbage can be obtained best by spraying the seedlings in the seedbed with Bordeaux mixture, to which a spreader and sticker, such as calcium caseinate, has been added and that spraying should commence as soon as the first leaves begin to develop. In order to avoid transferring the disease into the field, it is recommended that cauliflower seedlings be sprayed in the above manner and since the fungus can thrive on other cruciferous hosts, these should also be sprayed or eradicated. If the disease should appear on cauliflower seed plants in the field during the curd stage, it is recommended that they be dusted with copper lime dust every 10 days until the floral parts are well developed. Simultaneously, the insect pests must be kept in check by the application of insecticides.

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AMPHIDIPLOIDY IN *TRITICUM-AGROPYRON* HYBRIDS[1]

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The first successful attempts at hybridizing wheat and *Agropyron* grasses were made in the U.S.S.R. by Tzitsin in 1930. This work was carried on vigorously until the advent of the present war. Their chief aim has been the creation of perennial wheat, and fair success has been claimed in this respect.

In 1935 *Triticum-Agropyron* hybridization and breeding work was initiated at the Division of Forage Plants, Ottawa, the Forage Crops Laboratory, Saskatoon, and the National Research Council, Ottawa. The former two institutions undertook the hybridization and breeding work while Dr. F. H. Peto of the National Research Council, Ottawa, assisted materially in the early years of the project by cytological work and investigations on artificially induced polyploids.

The earlier breeding work on this project has been reported by Armstrong (1), Johnson and McLennan (5), Johnson (4), and White (17). The cytological investigations have been reported by Peto, (9, 10, 11), Peto and Boyes (12) and Peto and Young (13).

The two *Agropyron* species which we succeeded in crossing with various tetraploid and hexaploid wheats are *A. glaucum*, a hexaploid with $2n = 42$, and *A. elongatum*, a decaploid with $2n = 70$. Wheat crossed with the latter yielded partially fertile hybrids which we have carried on by line breeding methods. On the other hand crosses with *A. glaucum* yielded only sterile hybrids. To overcome this sterility we backcrossed the F_1 extensively with wheat. The crossing success was extremely low, being only 0.24 per cent. Cytological examination of the backcrosses by Peto (11) disclosed that in the first generation the observed chromosome number approximated that expected if unreduced female gametes were fertilized by normal haploid wheat gametes. The plants were in effect triploids. From a breeding standpoint they proved very unstable segregating rapidly into annual types. Of the few lines we have been able to carry through to stability for perennialism the seed more nearly approaches wheat in size than the selfed lines. They are also, much more readily threshed.

PRODUCTION OF AMPHIDIPLOIDS BY COLCHICINE TREATMENT

Another method of inducing fertility in the sterile glaucum hybrids is the doubling of the chromosome complement by artificial means. In 1937 Peto (10) doubled the chromosome number of Kharkov × *A. glaucum* through the application of alternating high and low temperature treatments on the early zygotic divisions. Colchicine treatment of the F_1 seeds or plants has proven more successful than heat treatments in inducing chromosome doubling. Raw (14), Sears (15), Peto and Boyes (12), Thompson

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et al. (16), and Berg and Oehler (2) have reported the production of amphidiploids of *Triticum* × *Agropyron, Triticum* × *Aegilops* and *Triticum* × *Secale* by the colchicine method.

A wide range of methods of securing chromosome doubling by the use of colchicine has been described by many workers. These methods involve varying the concentration of the drug, varying the duration of treatment and varying the stage in the plant's life cycle at which the treatment is applied. In 1941 we carried on some experiments in treatment methods having 4200 F_1 seeds from various *Triticum* × *A. glaucum* crosses available for experiment.

Five general types of treatment are listed in Table 1. All treatments were carried out at a temperature of 70° F. Within each type, variations were made in the concentration and duration of the time of the treatment. After the treatment the seed was washed, planted in trays and after a few weeks the surviving seedlings were transplanted to pots and later transferred to the field nursery. When the plants head and ripen they are carefully examined for fertile spikes. The fertility may be confined to only part of a spike or to one or two spikes per plant. Only infrequently are all the spikes of a plant affected. This criterion of fertility as an indication of chromosome doubling is quite reliable when it is recalled that F_1 diploids are completely sterile. Also heads with less than 3 seeds per head were not regarded as amphidiploids.

Table 1.—Comparison of results of various methods of colchicine treatment—1941

Lot No.	No. of seeds	Colchicine %	Colchicine Duration	Survival 6 weeks No.	Survival 6 weeks %	Survival 7 months No.	Survival 7 months %	Amphidiploids No.	Amphidiploids %
Series 1—Treatment of dry seeds									
1	197	.1	24–27 hours	69	35.0	59	29.9	1	0.51
2	8	.1	42	0	0.0	0	0.0	0	0.00
3	555	.2	18–27	257	46.3	228	41.1	9	1.63
4	151	.2	48	44	29.1	43	28.5	4	2.65
5	358	.4	24–27	108	30.2	107	29.9	11	3.07
6	40	.4	45	18	45.0	16	40.0	2	5.00
7	152	.6	16	17	11.2	17	11.2	2	1.32
8	97	.6	24	9	9.3	9	9.3	2	2.06
9	10	.6	45	3	30.0	3	30.0	0	0.00
10	60	.8	24	4	4.7	4	4.7	0	0.00
Total	1626			529	32.6	486	29.9	31	1.91
Series 2—Treatment of germinated seeds									
11*	200	.2	18–24 hours	55	27.5	53	26.5	5	2.50
12**	30	.2	18–24	4	13.3	4	13.3	0	0.00
13*	40	.2	6	18	45.0	16	40.0	3	7.50
14*	30	.4	24	4	13.3	4	13.3	0	0.00
15*	10	.6	24	0	0.0	0	0.0	0	0.00
16**	20	.6	18	0	0.0	0	0.0	0	0.00
Total	330			81	24.5	77	23.3	8	2.42

* Germinated for 18–24 hours
** Germinated for 24

TABLE 1.—COMPARISON OF RESULTS OF VARIOUS METHODS OF COLCHICINE TREATMENT—1941 —*Concluded*

Lot No.	No. of seeds	Colchicine		Survival				Amphidiploids	
		%	Duration	6 weeks		7 months		No.	%
				No.	%	No.	%		
Series 3—Plumule immersion									
17	48	.4	21 hours	32	66.7	32	66.7	1	2.08
18	67	.6	22	40	59.7	39	58.2	5	7.46
Total	115			72	62.6	71	61.7	6	5.22
Series 4—Germinated seed treated in partial vacuum									
19	124	.2	15 min.	63	50.8	63	50.8	11	8.87
20	834	.2	30	452	54.2	408	48.9	69	8.26
21	101	.2	45	700	69.3	61	60.4	3	2.97
22	136	.2	60	54	39.7	53	38.9	4	2.94
Total	1194			639	53.5	585	49.0	87	7.29
Series 5—Treated in .2% 24 hrs. followed by partial vacuum									
23	44	.2	30 min.	35	79.5	31	70.5	4	9.09
24	50	.2	10	23	46.0	23	46.0	2	4.00
25*	9	.2	30	5	55.6	5	55.6	3	33.33
Total	103			63	61.2	59	57.3	9	8.74
* Treated in .2% 42 hours									
Total	3368			1384	41.1	1278	37.9	141	4.19

The successful use of the first or dry seed method was first reported for the Gramineae by Myers (8). By this method the dry seed is placed in petri dishes and moistened with aqueous solutions of colchicine varying from 0.1 to 0.8%. The duration of treatment varied from 18 to 48 hours. A concentration of 0.1 had little effect while at the other extreme of 0.6 to 0.8 the seedling mortality was very high. The optimum treatment in this series appears to be 0.4% colchicine applied for 24 hours.

In series 2, the seed was first germinated 1 to 2 days on water-moistened filter paper in the petri dishes before treatment. The use of this method with cereal grains was reported by Dorsey (3) in 1939. It will be noted that the germinated seed is more sensitive to injury since a 0.4% concentration which was the optimum in dry seed treatment killed 87% of the seed while a 0.6% concentration was quite lethal. The optimum in the series appears to be treatment 13, which is 0.2% concentration for 6 hours.

In series 3, the seed was germinated until the plumules were ½″ to 1½″ long. The seedlings were then tied in bundles and suspended in a 0.4 to 0.6% solution for approximately a day. Here the 0.6% solution was quite effective, killing comparatively few plants and producing 7% amphidiploids. The advantage of this method is that the roots are kept clear of the solution and consequently there is less root injury.

In series 4, the partial vacuum method was applied to germinated seeds. A treatment of 15 to 30 minutes appears quite effective judging from the high percentage of amphidiploids produced. Treatment 22 indicates that if it is carried on for an hour the percentage seedling survival drops. This is the method which we consider to be the most effective.

Series 5, is a type of double treatment. The dry seeds were first treated 1 day with 0.2% then washed and allowed to germinate until the plumules showed and finally given a 15 to 30 minute treatment at 0.2% in partial vacuum. The results show this method to be quite effective.

In the material listed in this table it will be noted that the number of seeds tested for each treatment varied widely. This was because of the desirability of keeping the various lots of crossed seed intact. A considerable number of small lots of less than 10 seeds each are not included in the table. They were treated uniformly according to treatment 11.

Table 2 shows the frequency of amphidiploids obtained from F_1 seed of different female wheat parentage. None were obtained from *T. vulgare* × *A. glaucum*, *T. persicum* × *A. glaucum* or *T. timopheevi* × *A. glaucum* crosses, although amphidiploids had previously been obtained from the two former crosses. Hybrids of *T. diccoccum*, *T. durum* and *T. turgidum* female parentage have yielded the bulk of our amphidiploids. It is possible that in tetraploid wheat × *A. glaucum*, chromosome doubling can be induced more readily than in hexaploid × *A. glaucum*. It is more probable that it is a question of the relative competing ability of doubled and undoubled cells in the two amphidiploid types.

TABLE 2.—FREQUENCY OF AMPHIDIPLOIDS OBTAINED FROM VARIOUS *Triticum* × *A. glaucum* CROSSES—1941

Triticum female parent	Seeds treated	Survival after 7 months		Amphidiploids	
	no.	no.	%	no.	%
T. vulgare (4)	18	1	5.5	0	0.00
T. diccoccum (4)	243	54	22.2	6	2.47
T. durum (5)	1609	628	39.0	28	1.74
T. turgidum (4)	1775	654	36.8	102	5.74
T. pyramidale (3)	404	101	25.0	7	1.73
T. timopheevi (1)	147	52	35.4	0	0.00
T. persicum (1)	13	2	15.4	0	0.00
Total	4209	1492	35.4	143	3.40

TABLE 3.—AMPHIDIPLOIDS PRODUCED FROM *Triticum* × *A. glaucum* CROSSES

Wheat species	Variety	Year	Breeding no.	Present status
T. vulgare	Moseida	1939–40	S-108	F_4 ; testing and mult.
	Kharkov	1937	S-147	F_4 ; testing and mult.
T. diccoccum	Vernal	1938–39	S-91	F_5 ; testing and mult.
	Khapli	1940–41	S-132	F_2 selection
T. turgidum	No. 49	1939–40	S-107	F_4 ; testing and mult.
	Mirable	1940–41	S-137	F_2 selection
	Pseudocervium	1940–41	S-140	F_2 selection
T. durum	Akrona	1940–41	S-125	F_2 selection
	Kubanka	1940–41	S-128	F_2 selection
	Mindum	1940–41	S-131	F_2 selection
	Pentad	1940–41	S-134	F_2 selection
T. pyramidale	119328	1940–41	S-145	F_2 selection
T. persicum	Black Persian	1940–41	S-148	F_2 selection

DESCRIPTION OF AMPHIDIPLOIDS

Table 3 lists the amphidiploids that have been produced since 1937. These fall into two groups as far as breeding procedure and present status are concerned. The first group consists of the two strains S-108 and S-147 obtained from hexaploid wheats, and two strains, S-91 and S-107 from tetraploid wheats. These strains have been multiplied without any individual plant selection and are in the fourth or fifth generations. The second group derived from tetraploid wheat × *glaucum* crosses since 1941 are in the second generation. A few of the most fertile plants in each F_2 population were selected this past summer and these will be established as F_3 lines in 1944. (Figures 1 to 3).

Since all the amphidiploids have the common parent, *A. glaucum* the differences that exist between strains are largely due to morphological differences in the various wheat parents. These differences are quite marked. Comparing S-108 and S-147 the *vulgare* derived strains, several characters are seen to differ widely.

Character	S-108	S-147
Awning	Awnless	Strongly tip-awned
Spike density (10 central internodes)	105.5 mm.	87.5 mm.
No. of florets per spikelet	6 – 8	3 – 4
No. of seeds per spikelet	2.0	1.2
Width of non-flowering glumes	Wide throughout	Narrow at base
Attachment of flowering glumes	Strongly attached	Medium strong attachment
Rachis brittleness	Quite brittle	Medium tough
Threshability	Glumes attached to seed	Seed mostly free

While there are these differences apparent between strains they exhibit certain similarities. All appear to have about the same degree of winter-hardiness. The survival for the various strains during the past three winters ranged from 80 to 100% and did not alter appreciably from generation to generation. All are susceptible to winter injury from ice sheeting

FIGURE 1. Heads of Vernal Emmer × *A. glaucum* hybrids and parents. Left to right, Vernal emmer, sterile F_1 diploid, fertile F_3 amphidiploid and *A. glaucum*.

which was very severe on the plots in 1941-42. The perennial grasses such as timothy and Kentucky bluegrass are not greatly affected by this type of injury.

Most of the strains possess a fairly brittle rachis when ripe which may cause loss through shattering. This weakness may be overcome by harvesting slightly on the green side and allowing the grain to ripen in the

stook. Upon threshing there is usually a resulting mixture of free seed and seed with the glumes attached. If the concaves are set close to the cylinder to get a better separation much breaking of the slender seed occurs. The most satisfactory method appears to be to thresh with the glumes attached as this seed passes readily through the drill runs.

A. glaucum spreads moderately by stolons and this character is largely retained in the amphidiploids. This spreading propensity should prove of considerable value in forming a good sod and adding fibre to the soil. The four most advanced strains and several standard grasses were seeded in a replicated test this past summer in order to get some comparative data on forage yield next year. Besides the differences between strains there is also

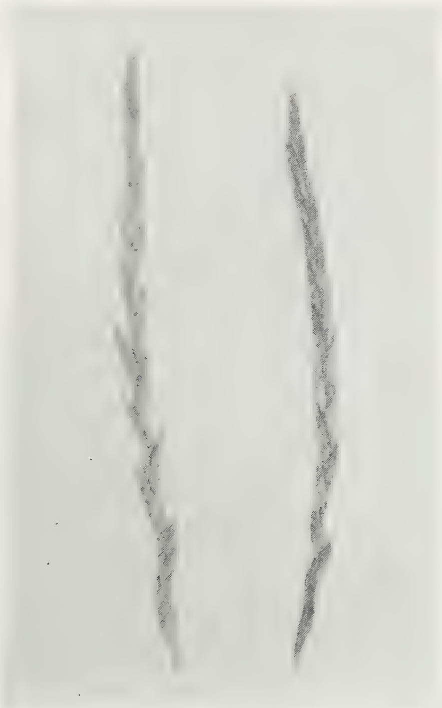


FIGURE 2. Heads of hexaploid wheat × *A. glaucum* hybrids. Moseida × *A. glaucum* left and Kharkov × *A. glaucum* right.

considerable variation between individual plants within a strain. This is especially true with regard to fertility. In a study of a random sample of 20 heads of S-91 the spike density was found to be 104.2 ± 2.01 mm. with a C.V. of 9.47% while the fertility per 10 spikelets was found to be 26.8 ± 1.16 with a C.V. of 19.44%. This high variability in fertility appears to have a cytological basis as will be shown later.

One of the requirements of the hybrid is that the seed will contain enough stored food to enable seedlings to emerge when planted at a depth of several inches. A depth of seeding test was conducted in the greenhouse to compare S-91 with wheat, *A. glaucum*, and crested wheat grass. The weight of 1000 seeds were: S-91, 22.8 gm.; vernal 34.2 gm.; Dawson's

TABLE 4. SEEDLING EMERGENCE OF GRASSES AND WHEATS SEEDED AT DIFFERENT DEPTHS

Material	Wt. per 1000 seeds (gm.)	½″	1″	1½″	2″	2½″	3″	3½″	4″
A. cristatum	1.8	60	90	95	35	10	0	0	0
A. glaucum	5.7	95	100	95	80	75	65	25	25
Vernal	34.2	89	83	56	50	61	83	83	78
D. G. Chaff	44.3	100	100	100	100	100	100	80	100
S-91	22.8	100	100	94	100	100	94	67	50

FIGURE 3. Increase block of Kharkov × *A. glaucum* amphidiploid. June 23, 1942.

Golden Chaff, 44.3 gm.; *A. glaucum* 5.7 gm.; and *A. cristatum* 1.8 gm. Seeds were sown at depths varying from ½″ to 4″. Results of the experiment given in Table 4 show that seeding emergency of S-91 was as good as wheat at depths of ½″ to 3″ but was not as good at greater depths. The emergency of the two grasses dropped gradually at depths exceeding 1½″. These results seem to indicate that S-91 can be seeded at a depth comparable to that used for wheat, hence it should be much easier to establish than crested wheat grass, which must have shallow seeding.

CYTOLOGICAL INVESTIGATIONS

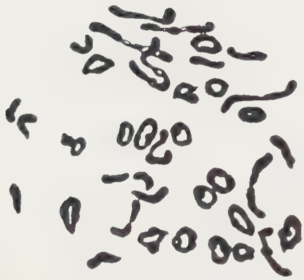
The cytology of the F_1 diploid generation of *Triticum* × *Agropyron* hybrids was investigated and reported by Peto (9) in 1936. He found in the F_1 of tetraploid *Triticum* × *A. glaucum* ($2n = 35$) an average of 29-22 univalents and 5-6 bivalents. The pairing of the bivalents was usually very loose, the attachment being end to end. The pairing did, however, indicate a partial homology between sets A or B of *Triticum* and one of the sets derived from glaucum. In the F_1 of hexaploid *Triticum* × *A. glaucum* where $2n = 42$ the amount of pairing approximated that found in the F_1 tetraploid wheat × glaucum. The set of chromosomes (C) introduced from the Vulgare parent was not homologous to a set from glaucum.

In the period 1941-43 the cytology of a small group F_2 plants and their F_3 progenies has been studied in the amphidiploid, *T. turgidum* × *A. glaucum*. In an amphidiploid of this parentage the $2n$ number would be 70 made up of 2 sets of wheat chromosome and 2 sets of glaucum and theoretically there should be perfect pairing, wheat *inter se* and grass *inter se*. The chromosome number might be expected to remain constant at 70 in the succeeding generations. Cytological examination did not bear out this latter supposition. A summary of the chromosome associations found in 5 F_2 plants is given in Table V.

TABLE 5.—CHROMOSOME ASSOCIATIONS IN F_2 PLANTS OF S-107

Plant no.	Chromosome associations of				Total chromosome no.
	1	2	3	4	
78	7.6	28.0	.33	.33	66
154	5.3	31.3			68
166	4.9	29.4	.10		64
292	4.0	20.0			64
435	5.0	32.0			69
Average	5.4	29.7	.10	.05	66.2

The five plants had $2n$ numbers of 64, 64, 66, 68 and 69. We may therefore deduce that in the F_1 parent plant the chromosome pairing was imperfect leading to chromosome loss in the male and female gametes. The pairing in the F_2 was also imperfect, 2-10 univalents being found in each cell examined. Trivalents and quadrivalents were also occasionally found. The tetrads of young pollen were for the most part regular and matured a high proportion of viable pollen.



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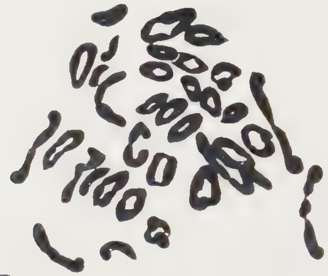

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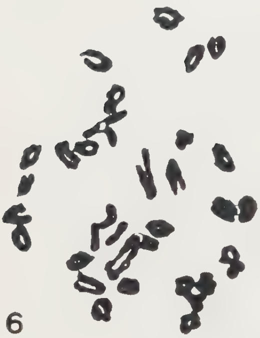

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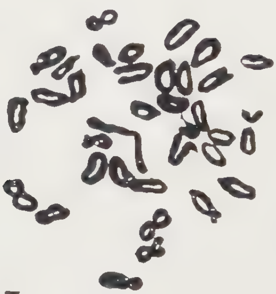

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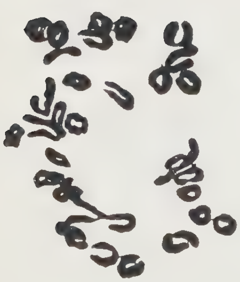

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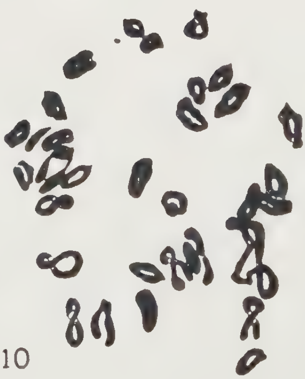

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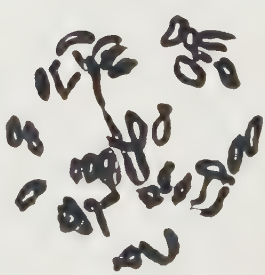

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DESCRIPTION OF TEXT FIGURES

FIGURES 4 – 11. Late diakensis and first metaphase of F_2 and F_3 plants of *T. turgidum* × *A. glaucum*.

FIGURE 4. F_2 plant 107–78, 11 × I, 26 × II, 1 × III.

FIGURE 5. F_2 plant 107–78, 4 × I, 29 × II, 1 × IV.

FIGURE 6. F_3 plant 107–166–5, 1 × I, 27 × II, 2 × III.

FIGURE 7. F_3 plant 107–435–8, 1 × I, 32 × II, 1 × III.

FIGURE 8. F_3 plant 107–435–2, 31 × II, 1 × IV.

FIGURE 9. F_3 plant 107–166–5, 30 × II, 1 × V.

FIGURE 10. F_3 plant 107–154–4, 1 × I, 30 × II, 1 × III, 1 × VI.

FIGURE 11. F_3 plant 107–154–13, 29 × II, 1 × III, 1 × VII.

Magnification of figures is × 690.

Peto and Boyes (12) also examined five F_2 plants from the comparable amphidiploid, Vernel Emmer × *A. Glaucum.* The $2n$ chromosome numbers were found to be 64, 68, 69, 70, and 70, a somewhat higher range than our F_2 group. About the same prevelance of univalents and multiple configurations were also observed.

The failure of all chromosomes to pair cannot be attributed to a lack of homology. On the other hand we know that pairing may be affected by extremes in temperature, genetic factors or conditions disturbing the cytodynamics of the cell. The latter is the more probable cause of lack of perfect pairing in amphidiploids as suggested by Kostoff (6). The double number of chromosomes in a cell of inadequate dimensions might disturb the pairing of homologues at the zygotene stage. There might also be a competitive effect in the set of 7 wheat and 7 glaucum chromosomes, which F_1 diploid studies showed to be partially homologous, which would prevent all wheat and all glaucum chromosomes pairing. Such weak pairing if it did occur might not be capable of persisting until late diakenesis and metaphase leaving the early partners as univalents. (Figures 4 to 11.)

Small F_3 progenies from the selected F_2 plants were also studied cytologically. The results are given in Table 6.

Pairing of chromosomes in the F_3 generation was more complete than in the F_2. This is shown in the fewer number of univalents per cell which averaged 2.2 for the F_3 and 5.4 for the F_2. It is also shown in the increased tendency to form multiple configurations of 3 and 4 chromosomes and more rarely larger associations of 6 and 7.

The F_2 averaged 1 trivalent per 10 P.M.C. while the F_3 averaged 2 per 10 cells. The F_2 averaged 1 quadrivalent per 20 cells while the F_3 averaged 4 quadrivalents per 20 P.M.C. The F_3 progenies had an average chromosome number of approximating that of their respective F_2 parents. There is no pronounced tendency to revert to a lower chromosome number.

The improved pairing in the F_3 generation over that of the F_2 may be considered significant and might be explained in part on the basis of improved or better adjusted cell dynamics and in part to the competitive elimination of male F_2 gametes with unfavourable chromosome combinations.

TABLE 6.—CHROMOSOME ASSOCIATIONS IN F_3 PLANTS IN S-107

Plant no.	Chromosome associations of							2n number
	1	2	3	4	5	6	7	
78 – 1	1.4	29.4		.4				61
(66) 2	1.0	33.0						67
3	3.3	30.8						65
4	.3	31.8	.7					64
7	3.2	29.5	.2					63
11	2.0	29.6		.5				64
12	.3	31.5	.3					64
14	3.6	21.5	.5					64
19	2.8	30.4	.2	.2				65
Average	2.1	30.4	.2	.1				64.1

TABLE 6.—CHROMOSOME ASSOCIATIONS IN F_3 PLANTS IN S-107—*Concluded*

Plant no.	Chromosome associations of							$2n$ number
	1	2	3	4	5	6	7	
154 – 2	3.4	30.9	.4	.1				67
(68) 4	1.7	32.5	.3			.3		70
5	.5	32.7						66
7	2.8	32.3	.5					69
8	2.2	32.8	.2	.4				70
9	1.0	32.0		.3				66
10	1.5	30.7		.3				64
11	2.3	32.3						67
13	1.3	31.6	.3				.3	68
14	2.7	32.5	.2					68
15	4.0	31.5						67
Average	2.1	31.9	.2	.1		.02	.02	67.4
166 – 1	3.0	33.0						68
(64) 2	2.6	32.4	.2					68
4	2.5	30.2		.3				64
5	3.7	28.0	.3	.7		.2		65
7	2.2	30.6		.4				65
8	3.7	31.0		.3				67
10	1.2	28.3						58
Average	2.7	30.3	.1	.2		.04		65.0
292 – 3	1.6	32.3	.2	.2				66
(64) 4	1.6	31.0	.4	.4				66
6	1.0	32.3		.4				67
7	3.2	29.2	.2					62
9	4.4	29.8	.2	.4				66
Average	2.4	30.9	.2	.3				65.4
435 – 1	1.6	31.6	.6					67
(69) 2	.4	31.4		1.0				66
3	1.2	34.0	.2					70
4	1.7	29.5	.7					63
5	1.3	32.3				.2		63
6	1.4	32.6	.4	.2				66
7	1.0	34.5						70
8	2.3	32.0	1.0	.3				70
Average	1.4	32.3	.3	.2		.02		67.3
Average	2.2	31.2	.2	.2		.02	.01	65.8

TABLE 7.—FREQUENCY OF PLANTS WITH VARIOUS NUMBERS OF SEEDS PER SPIKELET

F_3 progeny of	F^2 chromosome no.	0	.1 – .4	.5 – .9	1.0–1.4	1.5–1.9	2.0–2.5	Ave.
78	66	4	1	3			1	.45
154	68		1	1	4	5		1.29
166	64		3	1	2	1		.81
292	64	2			2	1		.82
425	69	1	1	2	1	3		.99

Notes were taken on the F_3 plants at maturity as to height, tillering, density of spike, awning and fertility. The distribution of the F_3 progenies in regard to fertility is given in Table 7. This is expressed in number of seeds per spikelet which was measured from the 10 central spikelets. It will be noted that the distribution in regard to fertility is quite variable ranging from 0-2.2 seeds per spikelet. Also that the progenies of the higher chromosome parents have the highest average fertility. Correlating the fertility of the 39 F_3 plants with their chromosome numbers, the coefficient of correlation was found to be 0.55 ± 0.112 which is moderately high and significant, 15 F_3 plants had 65 or less chromosomes and of these 2 had 1.4 and 2.2 seeds per spikelet while the other 13 had less than 0.6; 24 F_3 plants had 66-70 chromosomes and of these 16 had more than 1.2 seeds per spikelet while 8 had less than 1.2. It is apparent that low chromosome segregates as a rule are of a low grade fertility while the higher chromosome segregates have appreciably higher fertility.

In regard to the other agronomic characters such as height, tillering, and leafiness there was no correlation found with chromosome numbers. This is in keeping with the common observation of sterile F_1 diploids which as a rule are vigorous, tall and leafy.

DISCUSSION

A fairly analagous case of amphidiploid behaviour has been reported by Thompson, Britten and Harding (16); F_1 plants from the cross *T. turgidum* ($n = 14$) $\times$ *A. speltoides* ($n = 7$) were treated with colchicine yielding a small proportion of 42-chromosome amphidiploids which in many respects resembled *vulgare* wheat. The chromosome number and behaviour was studied in 53 plants selected at random from F_2, F_3, and F_4 generations. About 30% of the plants were found to differ from the normal expected chromosome number of 42 by 1 or 2 chromosomes. The great majority of the P.M.C. in 42-chromosome plants showed some unpaired chromosomes as well as associations of 3 and 4. It was also noted that plants with divergent chromosome numbers were not as fertile as those with the normal number.

This relationship between chromosome number and fertility is important from the practical breeding viewpoint. Even while increasing the amphidiploids without line selection as we are doing with the earlier productions, natural selection will work in our favour by eliminating the less fertile, lower-chromosome types. On the other hand deliberate selection of lines on the basis either of fertility or of high chromosome number as we are doing with the newer productions, will tend to produce stable breeding material.

SUMMARY

Sterility in *Triticum* $\times$ *A. glaucum* hybrids was overcome by inducing chromosome doubling by means of colchicine treatments of the F_1 seed.

Several methods of applying the colchicine are detailed and the effectiveness of the various methods is shown by the data on the percentages of amphidiploids secured.

In a cytological study of a group of F_2 plants and their F_3 progenies, chromosome pairing and stability was found to be improved in the third generation over that of the second.

A significant correlation was found in the third generation plants between chromosome number and fertility. This relationship favoured stabilization at the higher chromosome numbers.

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THE MIRID, *CALOCORIS NORVEGICUS* GMELIN, A STRAWBERRY PEST IN NOVA SCOTIA[1]

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For several years it has been observed in Nova Scotia that good stands of healthy-appearing strawberry plants would flower profusely but the berries would fail to develop or would form so-called "nubbins" or "buttons". Various explanations were proposed by growers and technical agriculturalists which included, among other things, incomplete pollination, frost, lack of fertility, drought, winter injury, root rot, tarnished plant bug, virus diseases and others. While the authors are not prepared to state that any or all of these factors may not at times be responsible, they now believe that the mirid, *Calocoris norvegicus* Gmelin, is the most frequent cause of malformed fruit of the strawberry in Nova Scotia.

For some years the strawberries at the Dominion Experimental Station at Kentville had been producing very poorly and "nubbins" frequently formed the greater proportion of the crop. It was the general opinion of the officials at the station that the soil on which the strawberries had been grown for a number of years had become "diseased" or "run out", and so in 1938 a plantation was set out in a new location. In 1939, when the Superintendent, Mr. A. Kelsall, showed it to the senior author, it supported a fine stand of plants which had borne a heavy bloom. In raising the clusters of half-grown berries to examine the conformation of the fruit numerous small greenish mirid nymphs were noted and some of the fruits were beginning to show malformations. It was at that time suggested to the Superintendent that this insect might be "stinging" the young fruits and thus causing them to be mis-shapen. Subsequent observations on this field showed that the malformed fruits increased in numbers and severity with the result that the crop was almost a complete failure. Observations on a nearby plantation the following year by Dr. J. M. Cameron, Provincial Entomologist, and Mr. Kelsall served to strengthen the suspicion that this insect was the causal agent of the malformed fruit.

Observations in numerous fields were made in 1941 and 1942 by field men of the Nova Scotia Department of Agriculture and some experiments on control of the insect were inaugurated in 1942 by officers of the Experimental Station, the Provincial Department of Agriculture and the Dominion Entomological laboratory, Annapolis Royal. In 1943 the junior author was employed practically full time during the summer on a detailed study of this insect and its relationship to strawberry malformations. Studies made by him with potted strawberry plants under cages in the greenhouse have proved beyond reasonable doubt that this insect causes fruit malformations similar to those found in many strawberry plantations throughout this province.

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Distribution of the Insect and Plants Attacked

Although it has been known that this insect was prevalent in many strawberry plantations in Kings County for the past two or three years, no attempt was made to survey the other strawberry growing areas in the province until the summer of 1943. All the principal producing areas are now known to be infested and the typically malformed fruits were found in all cases corresponding in severity to the prevalence of the insect.

It is not known whether the insect attacks the strawberry in other areas outside Nova Scotia, but it probably does. Knight (1) records it as "a European species now known from Connecticut, Maine, Massachusetts, New Jersey, New York, Nova Scotia, Quebec, where it occurs on grasses." An examination of references in the Review of Applied Entomology indicates that it is widespread in Europe where it is a pest of more or less minor importance on potato, beets, sugar beets, horse beans, beans, peas, flax, hemp, chrysanthemum, hops, red clover, apple, pear, young leaves of strawberry plants and cucumbers in greenhouses. It has been suggested that it is a vector of potato viruses but there is evidently some question as to the validity of this.

In Nova Scotia, in addition to strawberries, adults have been taken in numbers on sheep sorrel, tansy, alsike clover, red clover, timothy, garden beans, Swedes, mangolds, garden beets, wild radish and meadow fescue, and less commonly on parsnip, carrot, garden peas, buckwheat, potato, Canada blue grass and raspberry. Sheep sorrel, *Rumex acetosella* L., is the most common host, and it is thought that the prevalence of this plant in and about strawberry plantations may be an important factor in respect to injury to the strawberry fruits.

A few eggs of the insect have been found in the stems of sheep sorrel in the field. When caged on strawberry plants adults oviposited in the stems, and they probably also do so under field conditions. Lafferty *et al.* (2), reporting on the bionomics of this insect in Ireland, stated that it deposited eggs on corn marigold (*Chrysanthemum segetum*), ragwort, thistle, charlock, redshank, etc. Further studies are necessary to determine the plants selected for oviposition in Nova Scotia.

Life History

No detailed studies of the life history have been carried out in Nova Scotia. The small nymphs are found on strawberries when the earliest fruits on early varieties are about half grown. Probably for this reason these early fruits usually show less injury than the later ones. Adults begin to appear about the time the plantation is producing ripe fruit and continue to mature for at least 2 weeks. As soon as the adult stage is reached the insects leave the strawberry and probably disperse to the plants mentioned previously. Nymphs are often very common on sheep sorrel but no studies have been made to determine other plants on which they occur. Field observations suggest that the insect overwinters in the egg stage, and that there is but one generation a year.

Control

A satisfactory method of control has been found by growers who did not know that an insect was responsible for the fruit malformations. In the Masstown area in Colchester County where this type of injury has been prevalent on strawberries for at least 10 years, the senior author was shown fields in 1935 on which the straw mulch had been burned in the early spring. There appeared to be little doubt but that the quality of the fruit was better on these burned fields than on fields where the mulch had been handled in the customary manner, i.e., where it had been removed from the plants and placed between the rows. The practice of burning the mulch in the spring has now been adopted as standard in this district although the growers had not been aware of the true reason for the production of better fruit.

While the reason for the beneficial effects of burning the mulch has not been definitely established it appears probable that the heat of the fire destroys the overwintering eggs which have been deposited in the stems of the strawberry plants and weeds.

When it appeared that the injury found on strawberries in Kings County was similar to that at Masstown it was decided to try burning the mulch and arrangements were made to carry over a heavily infested field at the Experimental Station from 1941 to 1942. This field received a heavy mulch of oat straw in the fall of 1941, and under the supervision of the Superintendent, one-half was burned over in April under almost ideal conditions. Since the mulch was heavy the burning was deep and for a time it appeared that the plants were permanently injured. However, they improved rapidly later and by harvest time were fully as good as the non-burned area although possibly a little later. Observations made during the growing season clearly showed that nymphs of *Calocoris norvegicus* were much more numerous on the unburned than on the burned area. In the early part of the season none could be found on the burned area but they gradually migrated in, possibly from the sheep sorrel and other weeds in the surrounding areas as well as from the section of the plantation on which the mulch was not burned. Without going into details regarding injury to the various varieties included in this test it may be stated that, for the Senator Dunlap variety which appears very susceptible, on the burned area 48.1% of the fruits were free of malformations. Of those injured 32% showed slight, 29% moderate and 39% severe injury. On the unburned area, the same variety showed only 0.5% free from injury and of those injured 2% has slight, 2% moderate and 96% severe injury. Of the other varieties in the test only Claribel, a very late variety, showed any marked degree of resistance, with 26.3% of the fruits free of injury on the unburned area. There are some indications that varieties which ripen before or after Senator Dunlap may not be so susceptible to injury as the latter. The variety Premier (Howard 17) appears to be somewhat less susceptible to injury than Senator Dunlap; this, together with its earliness, probably accounts for the increasing popularity of Premier. This earlier ripening is possibly responsible for the lesser amount of injury even when in the same plantation.

The possibility that the insects or their eggs may be transported into strawberry plantations with the mulch, or that the mulch would protect the insects already in the plantation during the winter, was carefully

investigated. It was found that there were no significant differences in the degree of infestation following mulching with new oat straw, old oat straw, upland hay, salt marsh hay, spruce boughs and apple tree prunings. Leaving the plantation unmulched over the winter does not appear to be helpful in all cases although apparently it may sometimes reduce the infestation.

Sprays or dusts cannot be recommended at present with any degree of confidence. Extensive laboratory tests show that satisfactory kills may be secured by using nicotine sulphate, 1 pint per 100 gal.; anabasine sulphate, 1 pint per 100 gal.; pyrethrum, 3 lb. per 100 gal., and a commercial pyrethrum extract[4], 1 pint per 100 gal.; to each of which was added 4 lb. of laundry soap or soap flakes. The addition of hydrated lime, 4 lb. per 100 gal., to the nicotine sulphate spray did not give a satisfactory kill. A number of commercial wetting and penetrating agents used in combination with both the nicotine sulphate and pyrethrum were not as effective as the soaps. Nicotine sulphate with strongly alkaline soaps showed the most promise.

The results were unsatisfactory from field plots where pyrethrum and nicotine sulphate dusts were applied with a power driven cranberry type duster with a trailing dragsheet about 30 feet long.

Nicotine sulphate, 1 pint per 100 gal., to which was added 4 lb. of strongly alkaline laundry soap or soap flakes has given some promise under field conditions. However, it is necessary to apply this spray very heavily and with high pressure under practically ideal conditions. The trouble appears to be to get the insects adequately wetted with the spray as they are very active and drop to the ground at the least disturbance. As there is always a good deal of litter about the bases of the plants it takes a great deal of spray to wet this sufficiently to make contact with all of the insects.

In the laboratory tests there appeared to be little difference between small or large nymphs in susceptibility to sprays; nevertheless, it is suggested that under field conditions spraying should be started early where the insect is numerous since most of the injury is done to the blooms or to the small fruits and becomes more marked as the fruit increases in size. This fact is likely to give the impression that the injury is done as the fruits near maturity. Two or more applications may be necessary to give satisfactory control and only highly efficient power sprayers would be effective.

Since burning the mulch is not considered good horticultural practice and since the majority of strawberry growers do not have power sprayers, and in many cases there are no power sprayers available for miles around, it is felt that other methods of control should be investigated.

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[4] One U.S. gal. contains extractives equivalent to 20 lb. pyrethrum flowers assaying 0.9% pyrethrins

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COMBINING BEAUTY WITH UTILITY IN ROSE BREEDING[1]

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The remarkably high ascorbic acid content of the fruit or hips of many species of rose is now well known, and particularly in Great Britain, Europe and Russia vast quantities of rose hips are harvested annually as a food supplement rich in vitamin C. The U.S.S.R. scientists, Iwanoff and Bukin (1), pointed out in 1937 that the flesh of freshly harvested hips of the rose species, *R. cinnamomea* and *R. acicularis* as grown in the northern and middle parts of the U.S.S.R. contained as high as 4·6% ascorbic acid and that the southern species, *R. canina*, contained 2·2%. Pyke and Melville (2) investigated the ascorbic acid content of the common rose species of Great Britain and likewise found that in general the northern species contained the highest content of ascorbic acid. These authors divided the rose species into four groups based upon the ascorbic acid content of the fresh fruit pulp exclusive of the seed.

TABLE 1.—THE ASCORBIC ACID CONTENT OF THE ROSE SPECIES OF GREAT BRITAIN

Group	Mg. per 100 gm.	Group	Mg. per 100 gm.
Group 1		Group 3	
R. Afzeliana	1000	*R. agrestis*	460
R. coriifolia	1080	*R. micrantha*	400
R. mollis	1260	*R. spinosissima*	340
R. Sherardi	1260	*R. obtusifolia*	420
Group 2		Group 4	
R. canina	550	*R. arvensis*	80
R. dumetorum	590	*R. stylosa*	190
R. tomentosa	690		

Analyses revealed that the flesh of the hips of the commonest roadside species in the coastal regions of B.C., namely, *R. nutkana*, contained 1200 to 1370 mg. ascorbic acid per 100 gm., a content equivalent to or slightly higher than the values in the high group in Pyke and Melville's list for Great Britain.

An enquiry by a British Columbia nurseryman led to the analysis of a number of rose hybrids of local origin. The ascorbic acid values in Table 2 were obtained by the method of Ballentine (3) and are contrasted with the content of *R. nutkana* and *R. gymnocarpa* (two native species); *R. Moyesii* (a parent of *Rosa Eddieii*); Hoosier Beauty (a horticultural variety) and the flesh of freshly harvested ripe tomatoes.

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TABLE 2.—THE ASCORBIC ACID CONTENT OF A NUMBER OF ROSE HYBRIDS, TWO ROSE SPECIES FROM THE COAST OF B.C., HORT. VAR., HOOSIER BEAUTY, AND RIPE TOMATOES*

	Ascorbic acid Mg. per 100 gm.
Rose hybrids	
1. *Rosa Eddieii*	2780
2. *R. rugosa* hybrid	35 (mouldy)
3. *R. rugosa* hybrid	505
4. *R. rugosa* hybrid	633
5. *R. rugosa* × *canina*	123
6. *R. rugosa* hybrid Kitania	792
7. *R. rugosa* × *canina* hybrid	98
8. *R. canina* (Bröogs)	222
9. *R. Moyesii* × *nutkana*	1240
10. *R. multiflora* hybrid	56
11. *R. canina* (Bröogs) × *rugosa*	123
12. R. "Sweet Briar" (Macdonnell)	223
Rose species	
R. nutkana	1266
R. gymnocarpa	246
R. Moyesii	2383
Rose variety	
"Hoosier Beauty"	171
Tomato variety	
"Best-of-all" (ripe)	30

* Expressed as mg. per 100 gm. flesh as harvested.

The high ascorbic acid content of the hips from hybrids No. 1 and No. 9 were of particular interest, and an enquiry revealed that both were derived from the same cross, namely, between the common coastal species *R. nutkana* and *R. Moyesii.* Since the hips of hybrid No. 1 contained more than double the ascorbic acid content of *R. nutkana* it was of interest to discover later that the other parent, *R. Moyesii*, as grown near Vancouver contained 2383 mg. per 100 gm. of flesh, a content almost as high as the hips of hybrids No. 1, registered at Ottawa as *Rosa Eddieii.* It was also of interest that the hips of this hybrid were over twice the size of those of the native parent *R. nutkana*, and that the flesh was softer and much more palatable than the native species. Also, the seeds were fewer in number and larger in size and could be removed more easily from the flesh which is an advantage for jam making purposes.

Although the hips of *Rosa Eddieii* were slightly larger and more palatable than those of its parent *R. Moyesii*, nevertheless in type and general appearance they were very similar.

These studies are suggestive that the high ascorbic acid content of the hips of certain rose species together with characteristics that affect their palatability can be retained in a rose breeding project thus combining beauty with utility.

SUMMARY

The possibilities of combining beauty with utility in rose breeding is illustrated by the high vitamin C (ascorbic acid) content of the hips of the hybrid rose registered at Ottawa as *Rosa Eddieii.* The hips of this hybrid

contained 2·7% ascorbic acid based upon the fresh weight. The hybrid was a selection from a cross between *R. nutkana*, a B.C. coast species and *R. Moyesii* each containing an exceptionally high ascorbic acid content, namely, 1·3% and 2·3%, respectively.

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